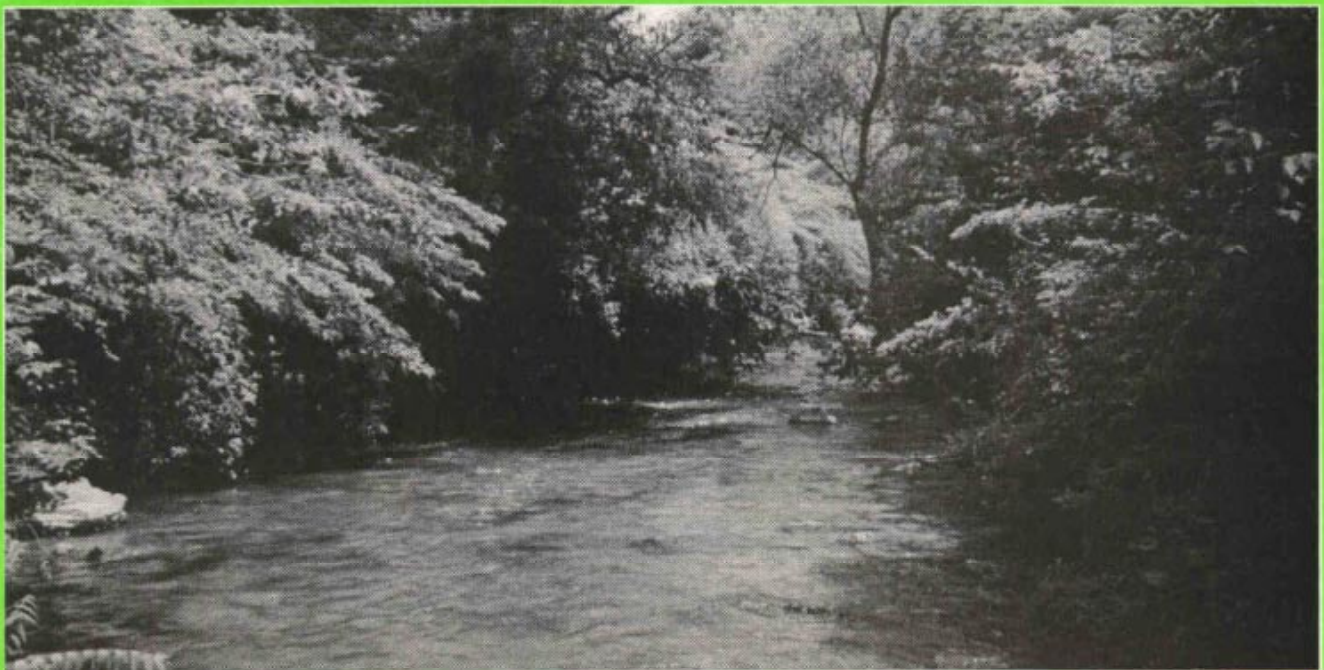


GUNPOWDER RIVER BASIN

ENVIRONMENTAL ASSESSMENT OF STREAM CONDITIONS



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CHESAPEAKE BAY AND
WATERSHED PROGRAMS
MONITORING AND
NON-TIDAL ASSESSMENT
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The Maryland Department of Natural Resources (DNR) seeks to preserve, protect and enhance the living resources of the state. Working in partnership with the citizens of Maryland, this worthwhile goal will become a reality. This publication provides information that will increase your understanding of how DNR strives to reach that goal through its many diverse programs.

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Secretary
Maryland Department of Natural Resources

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GUNPOWDER RIVER BASIN

ENVIRONMENTAL ASSESSMENT OF STREAM CONDITIONS



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December 1997

**Maryland Department of Natural Resources
Resource Assessment Service
Monitoring and Non-Tidal Assessment Division
580 Taylor Avenue
Annapolis, Maryland 21401**

Governor Parris N. Glendening

FOREWORD

The Maryland Department of Natural Resources (DNR), Monitoring and Non-tidal Assessment Division, prepared this report with financial assistance provided by the Coastal Zone Management Act of 1972, as amended, administered by the National Oceanic and Atmospheric Administration (NOAA). The report was funded in part by DNR's Coastal Zone Management Program pursuant to NOAA award number NA67OZ0302. In addition to this report, basin reports are also being prepared for the Elk and Bush river basins as part of this project.

On the cover: Big Gunpowder Falls near Lineboro in Carroll County. Photo by Niles Primrose.

Much of this report is based on results of the 1996 Maryland Biological Stream Survey (MBSS), a program funded primarily by the Power Plant Research Program and administered by the Maryland Department of Natural Resources. Field data for the Gunpowder River basin were primarily collected by the University of Maryland's Wye Research and Education Center under contract number MA96-003-003 to DNR. Analyses of water chemistry samples were conducted by the University of Maryland's Appalachian Laboratory (AL) under contract no. MA96-002-003. Much of the initial data analysis for this report was conducted by Versar, Inc. under Contract No. PR-96-055-001\PRFP-44 to DNR's Power Plant Assessment Division.

This report helps fulfill two outcomes in DNR's Strategic Plan: #1) A Vital and Life Sustaining Chesapeake Bay and Its Tributaries, and #2) Sustainable Populations of Living Resources and Healthy Ecosystems.

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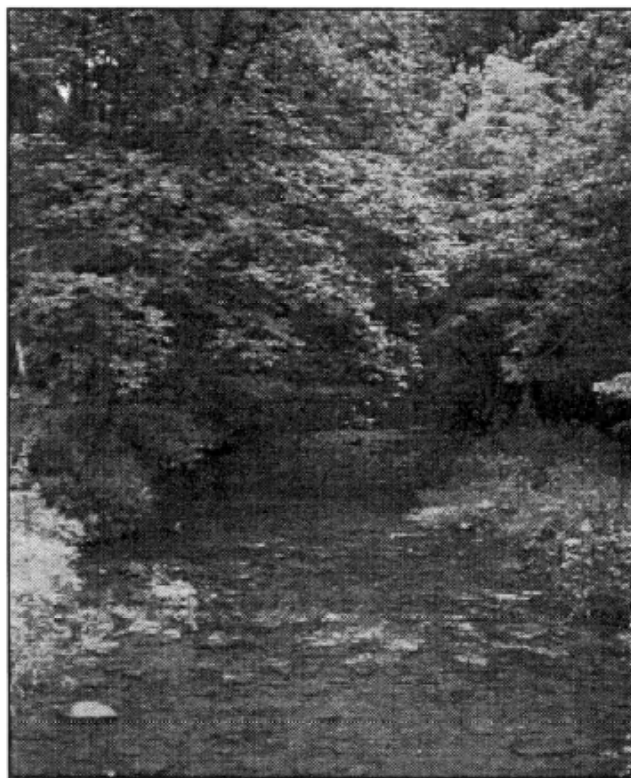


Photo by Niles Primrose

We also are grateful to those who reviewed this report: Ron Klauda, Niles Primrose, Joann Wheeler, and Carol Towle of DNR; Ken Belt and Bill Stack of Baltimore City Department of Public Works; Charles Conklin of the Gunpowder Valley Conservancy; and Steve Stewart of Baltimore County Department of Environmental Protection and Resource Management. Line drawings of reptiles and amphibians were done by Howard Coneybeare and originally appeared in ONR (1976).

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EXECUTIVE SUMMARY

This report describes existing aquatic resource conditions during 1996 in first, second, and third order non-tidal streams in the Gunpowder River basin in Maryland. The report also begins to assess water quality and habitat problems in the basin, as well as defining areas of high ecological quality. This information may prove useful as watershed-specific strategies for restoring water quality in Chesapeake Bay watershed are developed and refined.

The primary source of information for this report is the Maryland Biological Stream Survey (MBSS) conducted by Maryland Department of Natural Resources (DNR) in 1996 to characterize Maryland streams, including those within the Gunpowder River basin. Although the primary focus of the MBSS is on acid deposition impacts, the survey is also being used for other purposes such as reporting on watershed conditions. The MBSS is a statewide survey of first, second, and third order streams designed to characterize current biological and habitat conditions and provide a basis for assessing future trends. The probabilistic design used for the survey, in which all streams have a known probability of being sampled, allows for quantitative estimates of stream characteristics and conditions. This approach is not unlike taking a random sample of voters to determine who is likely to win an election.

FINDINGS

Water Quality

- Acidity is not a water quality problem in Gunpowder River basin streams. All stream miles in the basin had pH greater than 6—the level above which most biota thrive.
- None of the stream miles in the basin had acid neutralizing capacity (ANC) less than 0 $\mu\text{eq/L}$, indicating that none of the streams in the basin are chronically acidified. About 13% of the stream miles in the basin had ANC levels less than 200 $\mu\text{eq/L}$ and are susceptible to episodic, storm-

related acidification. The remainder of the stream miles had ANC levels greater than 200 $\mu\text{eq/L}$ and are considered well-buffered and relatively immune to acid deposition impacts.

- None of the stream miles in the basin had summer dissolved oxygen levels lower than the state water quality criterion of 5 mg/L. This suggests that excessive loadings of oxygen-demanding organic chemicals to streams in the basin are not a problem.
- Elevated nitrogen levels (nitrate greater than 1 mg/L) occurred at all stream miles in the basin. The primary source of nitrates appear to be agriculture, but urban runoff and acid deposition are also likely contributors.

Physical Habitat

- Twenty-four percent of the stream miles in the basin had either poor or very poor instream physical habitat scores—the amount and diversity of stable materials such as riffles, logs, undercut banks, and snags. Causes of degraded habitat include channelization, sedimentation, and riparian zone deforestation.
- Almost 30% of the stream miles in the basin had unstable stream banks, while only 2% of the stream miles had stable banks. Eroding stream banks may be an important source of sediment and nutrients to the 2 drinking water reservoirs in the basin (Prettyboy and Loch Raven), the Gunpowder River estuary, and to the Chesapeake Bay.
- In general, riparian zones along streams in the basin were in fair condition. About 50% of all stream miles had vegetated riparian zones greater than 50 meters wide, but about 15% of the stream miles contained no buffers. Forest was the dominant vegetation type in riparian zones greater than 6 meters wide. Forty-five percent of the stream miles were well-shaded.

Fish

- A total of 40 fish species were collected in the basin, including 5 gamefish: largemouth and smallmouth bass, rainbow trout, brown trout, and brook trout. With a population estimate of 66,000 individuals, brook trout were the most abundant gamefish collected. None of the fish species collected are listed as threatened, rare, or endangered in Maryland.
- About 3.2 million fish live in non-tidal streams in the basin. The most abundant fish species in the basin was the blacknose dace, a pollution-tolerant species, estimated at more than 900,000 individuals.
- Only two species of migratory fish, sea lamprey and American eel, were found in the non-tidal streams of the basin. Of these, American eels were the most abundant, with an estimated population of 56,000 individuals. One reason for the relatively low numbers of migratory fish in the basin is the 23 known barriers to fish migration which restrict upstream movements. American eels can climb over many barriers in the Gunpowder River basin that are impassable to other migratory fish.
- About 75% of the fish species collected in 1996 are native to the Chesapeake Bay drainage. Many non-native species were introduced to provide recreational fishing opportunities.
- Based on DNR's Index of Biotic Integrity for fish, about 56% of the stream miles in the basin were in either good or fair condition, while none were in very poor condition. Most good sites were in the northern third of the basin.
- With forest clearing and other human-related landscape alterations, summer stream temperatures in the Gunpowder River basin have most likely

increased along with nutrient levels. As a result, brook trout populations have probably declined and were found at only 8 of the 45 sites sampled.

Benthic Macroinvertebrates

- Based on the Hilsenhoff Biotic Index, nearly 70% of all stream miles in the basin were assessed as good, while the remaining 30% were assessed as fair. No stream miles were assessed as poor using this index.
- Forty-eight of the 123 stream-dwelling benthic macroinvertebrate families found in Maryland were collected in the Gunpowder River basin. Dominant types were non-biting midges (true flies), mayflies and caddisflies.

Freshwater Mussels

- Freshwater mussels were observed at only 2 of the 45 sites sampled in the basin. Eastern elliptio (*Elliptio complanata*) and the Asiatic clam (*Corbicula fluminea*) were the only 2 species collected in the basin.

Reptiles and Amphibians

- Reptiles and amphibians were present at 91% of the sites sampled in the basin. A total of 13 species of frogs, toads, turtles, salamanders, and snakes were observed.

Summary

- The major impacts to non-tidal streams in the basin appear to be nitrogen enrichment, streambank instability, high riffle embeddedness, and loss of forested riparian zones. The most likely reasons for these impacts are stream alterations resulting from agricultural activities and urban sprawl, especially in the southern part of the basin.

CHAPTER ONE

INTRODUCTION

Purpose of Report

This report describes existing aquatic resource conditions in first, second, and third order non-tidal streams in the Gunpowder River basin in Maryland. The report also begins to assess water quality and habitat problems in the basin, along with areas of high ecological value. This information may prove useful as specific strategies for restoring water quality in Chesapeake Bay and its tributaries are developed and refined.



The Gunpowder River basin, one of Maryland's 18 major river basins, lies in the north central part of the state. A small portion of the basin drains into Maryland from Pennsylvania.

Stream Resources

The flowing waters of Maryland represent a vital lifeblood to its residents. In addition to providing a source of drinking water and water for agricultural and industrial uses, Maryland's streams and rivers provide recreational opportunities, attract tourists and support commercially important fish and shellfish species. The riparian corridors associated with streams and rivers contain some of the richest and most diverse plant and animal communities found anywhere in the state. Forested riparian corridors also temper the effects of heavy rainfall and storm water runoff, shade the stream channel, increase bank stability and contribute leaf litter and woody debris—sources of food and habitat

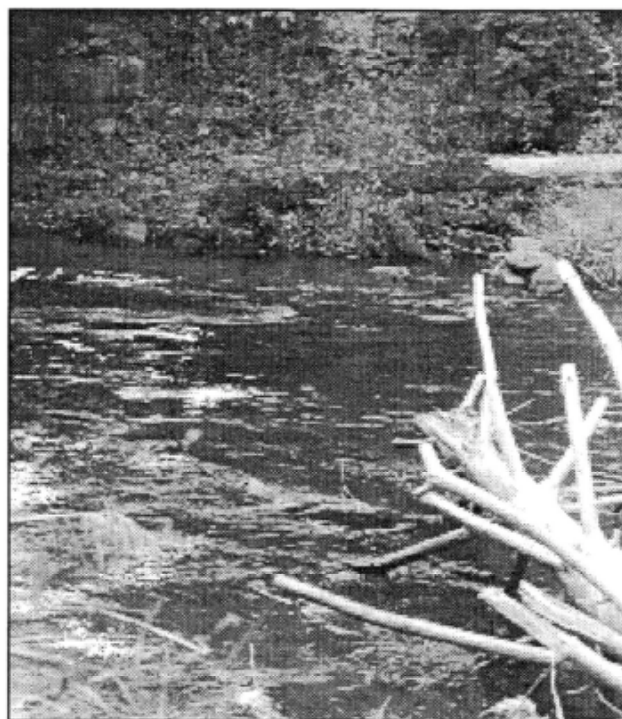


Photo by Tony Alfred

Big Gunpowder Falls

for stream biota. In many cases, the aesthetic attraction of streams and rivers have served as the primary catalyst for economic re-development. Nearly all of the rivers and streams in Maryland, including those in the Gunpowder basin, drain into Chesapeake Bay—therefore the quality of streams and rivers in the Gunpowder River basin has a direct impact on the health of Chesapeake Bay. As most Marylanders know, the Bay is one of the state's most important economic and natural resources.

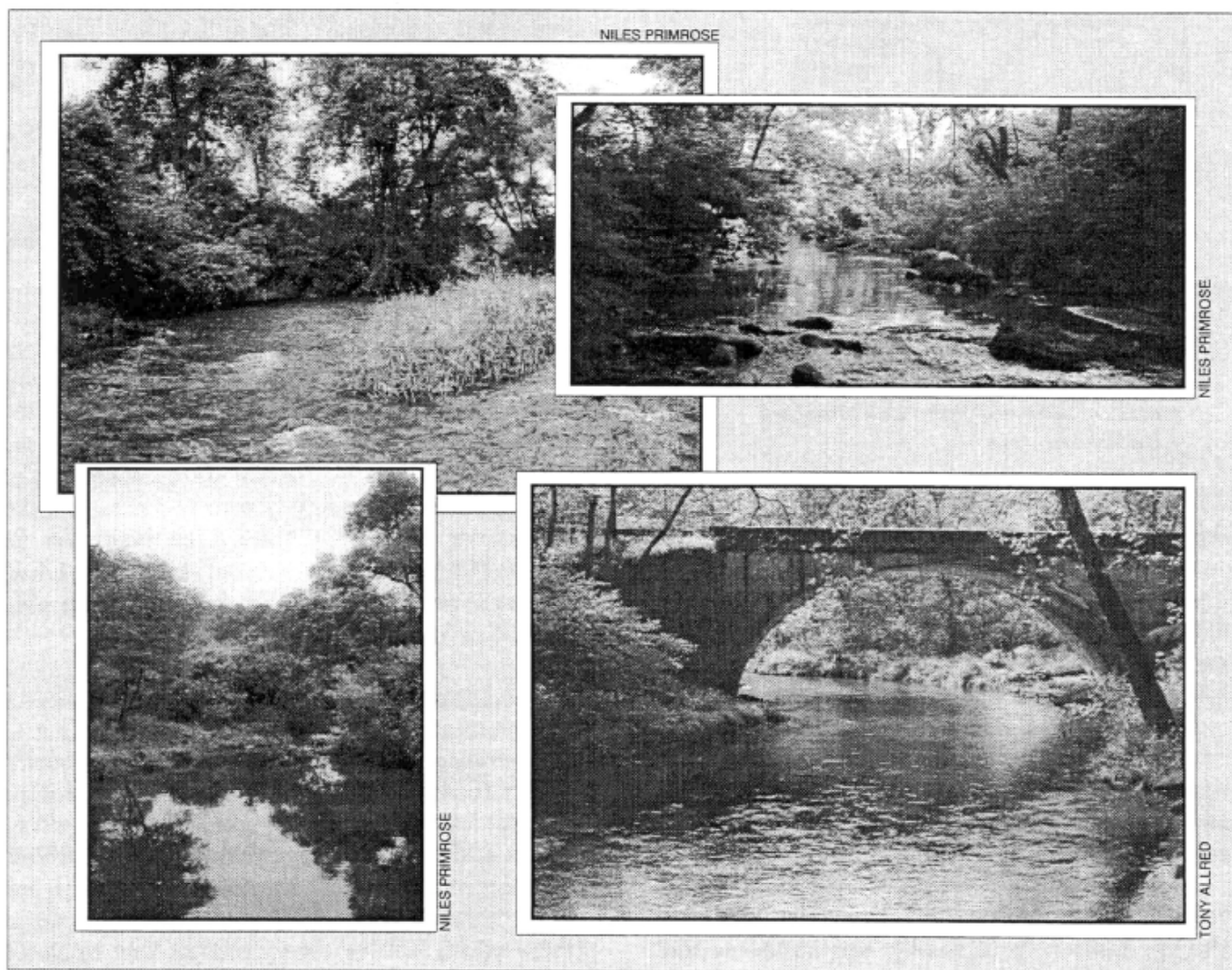
In spite of these values, Maryland's streams and rivers have been abused and neglected, often converted to flood routing systems, or used as drains for unwanted wastes. Increasingly, Marylanders are realizing that our mistreatment of natural resources is neither economically nor environmentally sustainable. Efforts are being made to restore degraded stream systems and to protect healthy streams. In the end, the success of these efforts will be determined by how much we cherish these most valuable natural gifts.

Information Sources for This Report

The primary data source for this report is the Maryland Biological Stream Survey (MBSS) conducted by DNR. The MBSS is a statewide survey of first, second, and third order streams designed to characterize current biological and habitat conditions and provide a basis for assessing future trends. The probabilistic design (all streams have a known probability of being sampled and sites are randomly selected for sampling) used for the survey allows unbiased estimates of stream characteristics and conditions. For example, the abundance of a given fish species in a basin can be validly estimated using the MBSS design. Because first, second, and third order streams represent about

91% of the tidal and non-tidal stream miles in the Gunpowder River basin, MBSS results should accurately represent overall stream quality in the basin. Examination of conditions in small streams also enables identification of specific problem areas where local protection, enhancement, and restoration efforts could be focused.

To provide some comparison of present and past conditions, historical information is presented where appropriate and available. In addition, information on land use, hydrology and other aspects of the basin are also represented so that the conditions observed in streams can be placed in context of human activity.



CHAPTER TWO

BASIN DESCRIPTION

This chapter uses existing information to provide a general overview of the Gunpowder River basin, including ecological, recreational and economic resources. This overview provides a context for interpreting the assessment of stream conditions found in Chapter 4.

HISTORY

As early as 10,000 B.C., hunting-gathering nomadic tribes lived in the Gunpowder basin. With plentiful shellfish to harvest, many settlements were established in the floodplain areas between 8,000 and 1,000 B.C. During the following 1,000 years, fortified villages appeared and agriculture became a dominant way of life (DNR 1983).



Photo by Niles Primrose

The boulder-strewn Big Gunpowder Falls provided water power for several mills during the 17th and 18th century.

In the 1600s and 1700s, Europeans settled in the basin. Many mills were built along the river banks to take advantage of the river's abundant water and the power it provided on its way over the "falls". In the 1700s, ironworks were developed to exploit the river's mineral deposits. One copper mill produced copper sheeting used in the first U.S. Capitol dome. The basin is also the site of the first papermill in Maryland—built to manufacture paper for the Continental currency following the American Revolution (DNR 1983).

How did the Gunpowder River get its name?

Saltpeter, an ingredient of gunpowder, was found along the banks of the Gunpowder when Europeans settled in the area during the 1600s. The settlers traded gunpowder with the native Algonquins. Later, several gunpowder manufacturing mills were constructed along the banks of the river, which became known as the Gunpowder in 1658 (Kernan 1997).

During the 1800s, much of the land within the basin was cleared of trees to prepare land for crops such as tobacco, cattle, and dwellings. Much of the wood from these forests was used for shipbuilding and to produce coke for use in blast furnaces. Since the incorporation of Baltimore as a city about 200 years ago, urbanization has increased dramatically in the lower part of the basin.

BASIN CHARACTERISTICS

The Gunpowder River basin drains about 478 square miles of Baltimore, Harford, and Carroll counties in Maryland. A small portion of the basin (about 11 square miles) drains into Maryland from York County, Pennsylvania (USGS 1953). The mainstem of the river, often referred to as the Big Gunpowder Falls, begins in Pennsylvania and follows a southeasterly course through Prettyboy and Loch Raven reservoirs. The Little Gunpowder Falls joins the mainstem at a tidal embayment which forms a delta and then flows into Chesapeake Bay.

DNR has classified the Gunpowder River as a river with natural, recreational and cultural values of regional or local significance (DNR 1985). Its highly significant resources include critical ecological areas, public lands, and recreational opportunities such as canoeing and sport fishing. Big Gunpowder Falls has been nominated for scenic river status.

Most of the basin lies within the Piedmont Plateau, an area characterized by rolling hills. A small portion of the lower basin lies within the Coastal Plain, an area of mostly sandy soils and fairly flat landforms. The fall line separates the two areas.

What is the fall line?

A line roughly following Interstate 95 joining areas of relatively steep gradient on several rivers on Maryland's western shore. The line marks the geographical area where each river descends from the hilly Piedmont Plateau to the flat and sandy Coastal Plain.

Much of the forested area in the basin is dominated by stands of tulip poplar, black, red, and white oaks, and pignut and mockernut (Brush *et al.* 1977). Above Prettyboy Reservoir, chestnut oak is abundant. In the riparian corridor along larger streams, sycamore, green ash, and box elder tend to be abundant. At lower elevations, river birch and sycamore are common, and chestnut oak and flowering dogwood are abundant. Other common species in the basin include: black cherry, red maple, ironwood and American beech.

In recent years, a non-native shrub called multiflora rose has invaded many forested areas of the Gunpowder River basin. Widely touted by soil conservation professionals in the 1950s and 1960s as a means of enhancing wildlife habitat on farms and in backyards, this plant has spread into every drainage basin in the state and now constitutes a significant threat to riparian corridor reforestation efforts. Multiflora rose is an opportunist that colonizes cleared areas such as pastures and timber cuts and is often so successful that virtually no other plants can compete with it. Because aquatic insects have adapted over thousands of years to feed on leaves fallen from native trees and shrubs, the takeover by multiflora rose is reducing the amount of food available to our native insects which form a vital food base for our fishes. An additional problem is that, unlike mature trees whose roots typically extend below the water level of a stream, the roots of multiflora rose often do not protect the lower stream bank where erosion is most severe. Like most other introductions of non-native species, the introduction of multiflora rose has resulted in unforeseen negative consequences.

Silt, sand, and loam are the dominant soil types in the basin. These soils are primarily well-drained and deep and range from moderately to rapidly permeable. Slopes generally range from 0 to 10 % (MOP 1991).

Because it is close to the Chesapeake Bay and coastal waters, the climate in the Gunpowder basin is generally humid and mild. Based on data collected by the National Climatic Data Center (1996), average annual temperature is about 53 °F. Annual precipitation averages 43 inches and long-term monthly averages range from 2.7 inches in February to 4.4 inches in June and August. In spite of the relatively even distribution of rain throughout the year indicated by long-term averages, in any given year some months have no rain while others may greatly exceed the average amount.

There are 466 miles of first, second, and third, order non-tidal streams in the Maryland portion of the basin, based on a 1:250,000 scale U.S. Geological Survey map. For a description of stream order, see Chapter 3. First order streams make up 68% of the total non-tidal stream miles, while second and third order streams constitute 15% and 8% of the non-tidal stream miles, respectively. Another 9% of all the stream miles in the basin are fourth order or larger.

About 1.5 million people in the Baltimore metropolitan region receive their drinking water from two reservoirs on the Big Gunpowder Falls. Prettyboy reservoir (upstream) and Loch Raven reservoir (downstream) together hold about 43 billion gallons of water. The water is delivered from the reservoir to the Montebello Filtration Plant, in northeast Baltimore city via a 12-foot diameter pipe. With the completion of Loch Raven dam in 1914, migratory fish such as American eels were eliminated from the upper watershed (DPW 1981).

LAND USE AND HUMAN POPULATION

Land use in the basin is dominated by forest (35%) and agriculture (36%), but 22% of the watershed area is classified as urban (Figures 1 and 2). The remaining areas are classified as wetlands (1%) or water (6%). Based on the 1990 census, 455,000 people live in the basin or about 9% of Maryland's population.

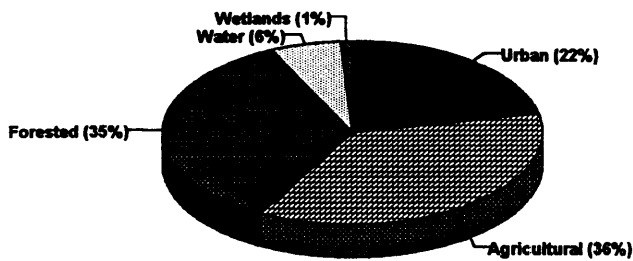


Figure 1. Land Use (MOP 1994) in the Gunpowder River basin.

At present the basin remains mostly rural, but development pressure is significant and poses a threat to natural resources in the basin. Between 1990 and 2020, the human population is predicted to increase by 15% (DNR 1997a), with development extending out into areas further and further from metropolitan Baltimore.

WATER QUALITY

Water quality in the Gunpowder River basin generally ranges from poor to good (DNR 1996a) with most stream and river segments rated as good. Water quality problems include elevated bacteria and nutrient levels associated with agricultural and urban/suburban runoff, and elevated suspended sediment loads from agricultural runoff, erosion, and construction activities (DNR 1996a).

Maryland Department of the Environment (MDE) classifies all surface waters in Maryland into 4 categories or "uses" (COMAR 1995). All waters of the state are protected for Use I—waters suitable for contact recreation, fishing, and protection of aquatic life and wildlife. This is the least protective use. Use II waters are suitable for shellfish harvesting while uses III and IV are designated as natural and recreational trout waters, respectively. Special designations are given for waters protected for drinking water supplies.

Several rivers and streams in the basin have more stringent protection than Use I. Use III waters are: portions of Little Gunpowder Falls, Long Green Branch, and Sweathouse Branch and all their tributaries, and all tributaries upstream of Loch Raven

dam. Use IV waters include Whitemarsh Run and all its tributaries. The Big Gunpowder Falls above Loch Raven Dam and all its tributaries, including Prettyboy Reservoir, are designated as drinking water supplies (DNR 1996a).

The Gunpowder Watershed Project

The Gunpowder Watershed Project is a cooperative effort involving the US Environmental Protection Agency, various State agencies, local governments (Baltimore County, Baltimore City, Carroll County, Harford County, York County (PA)), and the regional Baltimore Metropolitan Council. The goal of the project is to conduct a holistic watershed assessment of the Gunpowder River basin by answering specific concerns related to growth and development, water supply protection, excess nutrients, elevated temperatures, increased stormwater flows (volume and quality) and effects on stream erosion. Opportunities will be provided to link these concerns, prioritize resource management options and guide the development of a comprehensive management program in the basin. Because the basin is facing issues common to many urbanizing areas, the methods and findings developed should be generally applicable to many different river basins (DNR 1996a).

MDE has listed the following subwatersheds in the Gunpowder River basin as impaired: Gunpowder River, Bird River, Loch Raven Reservoir, and Middle River-Browns Creek. (MDE 1996). Nutrients and suspended sediments are the primary stressors thought to be causing impairment in these subwatersheds. These pollutants originate primarily from both non-point and natural sources. In addition, there are 12 municipal discharges and 72 industrial discharges with National Pollution Discharge Elimination System (NPDES) permits in the basin. Each facility discharges to surface waters (Siano 1997).

Since the mid-1980s, DNR has measured nitrogen at three sites on the Big Gunpowder River. Upstream of Prettyboy reservoir, nitrogen levels were assessed as

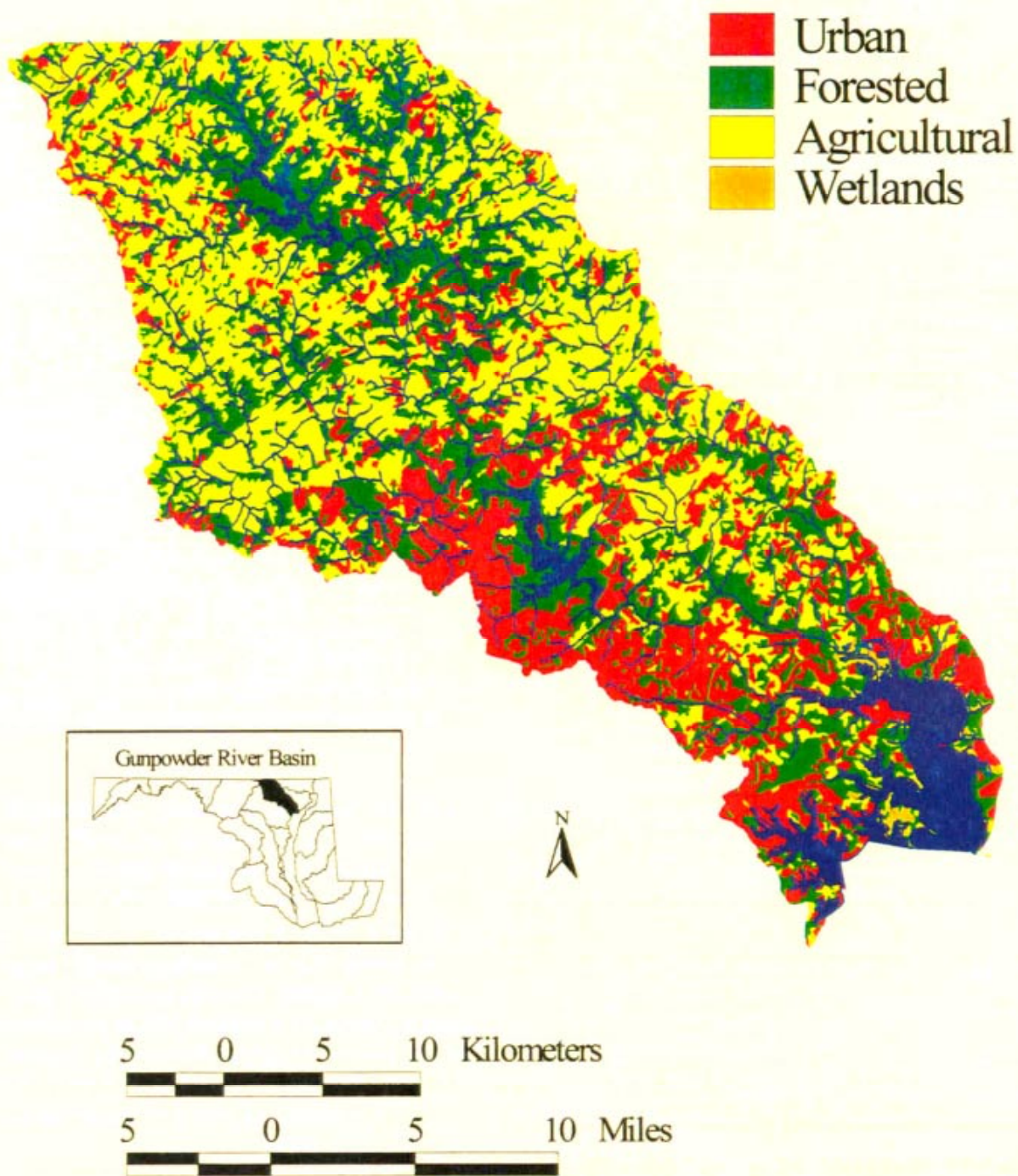


Figure 2. Land use (1994) in the Gunpowder River basin (MOP 1994).

very poor (total nitrogen greater than 3.15 mg/L). In the area between Loch Raven and Prettyboy reservoirs, and below Loch Raven reservoir, nitrogen levels were poor (total nitrogen between 2.04 and 3.15 mg/L) and fair (total nitrogen between 1.35 and 2.04 mg/L), respectively. There were no apparent trends in nitrogen levels between the mid-1980s and 1996 (DNR 1997b). In addition to nitrogen, runoff of phosphorus into these 2 reservoirs likely contributes significantly to eutrophication.

RESOURCE VALUES

Recreational Resources

The basin has several publicly-owned lands that provide numerous recreational opportunities for residents and visitors. Recreational opportunities include canoeing, picnicking, horseback riding, camping, swimming, hiking, boating, bicycling, and nature studies. Sections of the basin noted for canoeing are: Gunpowder Falls below Prettyboy Reservoir, Little Falls, Western Run and Little Gunpowder Falls (Gertler 1983). Tubing is a popular summer activity in the mainstem river between Prettyboy and Loch Raven reservoirs. There are excellent fishing opportunities in the river, the reservoirs, and the tidal portion of the basin.

The Baltimore Metropolitan region contains over 2 million residents — about 51% of Maryland's population. About 1.5 million of these people live within an hour's drive of Gunpowder Falls State Park (DNR 1983).

Gunpowder Falls State Park occupies about 11,500 acres. The park has more than 100 miles of trails, including the right-of-way of the former Northern Central Railroad. This right-of-way has been converted into a popular 21-mile multi-use (bicycling, hiking, etc.) corridor extending from northern Baltimore suburbs to Pennsylvania. Other popular park sites in the basin include Dundee Creek Marina, Days Cove Environmental Center, and the Hammerman Area's 1,500-foot riverfront beach. There are 15 marinas and 2 public boat ramps in the Gunpowder River estuary, and a public boat ramp for permit-holding boaters for each reservoir (DNR 1996b).

Ecological Resources

The tidal portion of the basin serves as spawning habitat for a number of fish species, including yellow perch, white perch, and several species of catfish. Blue crab abundance is also relatively high, and a number of predatory fish species (e.g., striped bass and largemouth bass) are known to frequent the tidal embayments and river.

Because it is both a living resource and provider of critical habitat for fish and crabs, submerged aquatic vegetation (known as 'SAV' in the Chesapeake Bay region) is a vital component of the tidal portion of the basin. In the late 1960s, SAV began declining in most of Chesapeake Bay. After hurricane Agnes deposited torrents of rainfall and millions of tons of sediment on the upper Chesapeake Bay in June 1972, SAV beds declined dramatically and have not yet recovered. The current estimate of SAV abundance in the tidal part of the basin is 168 acres; less than 20% of the immediate restoration goal established by the Chesapeake Bay Program and less than 3% of the ultimate restoration goal for the basin (EPA 1992; Orth *et al.* 1996). One ray of hope for the Gunpowder is that in spite of the low overall abundance of SAV in the basin, SAV has been increasing in the upper areas of the estuary that are most influenced by flows originating from within the basin itself.

More than 100 species of birds are known to nest in the basin (Robbins and Blom 1996). Bird watchers may enjoy seeing marsh hawks, great blue and green herons, and ospreys along the banks of the river. In winter, black ducks, Canada geese, and whistling swans can be seen in the lower portions of the basin (ACB 1987). Since 1993, at least one pair of bald eagles has nested in various places in Loch Raven reservoir and the Days Cove portion of Gunpowder Falls State Park, although they have apparently not reproduced (Scarpulla 1997; Conklin 1997).

Extractable and Renewable Resources

The basin contains few mineral deposits of commercial value, although sand and gravel are extracted from 6 locations and clay is mined from 5 locations in the Coastal Plain portion of the basin. Crushed stone (serpentine) and marble are also mined from 2 locations in the Piedmont portion of the basin.

Sand and gravel are used primarily to provide raw materials for local highway construction and maintenance (MGS 1996).

Calcite, or calcium carbonate, is mined from a large limestone quarry in the Gunpowder River basin. It is ground fine enough to use in tooth paste and coat chewing gum.

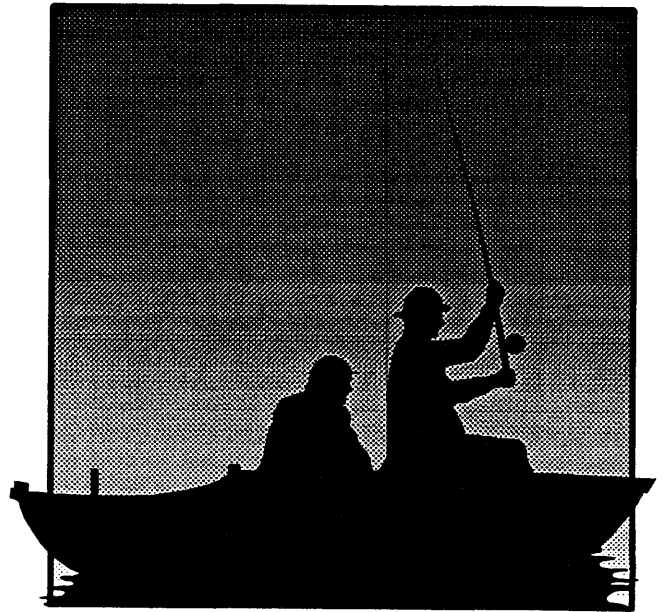
Timber resources in the basin are dominated by hardwoods, with tulip poplar and various oak species comprising the large majority of the harvest (Frieswyk and DiGiovanni 1988). Other species harvested in lesser amounts include soft maples, ashes, black walnut and black cherry.

Fishery Resources

Excellent recreational fishing opportunities are found in both the tidal and non-tidal portions of the basin. The two major reservoirs, Loch Raven (2,400 acres) and Prettyboy (1,500 acres), are popular with anglers. The most sought after species are yellow perch, black crappie, largemouth bass, and chain pickerel. In addition, more than 10,000 rainbow trout are stocked annually in Prettyboy reservoir by DNR and a number of anglers direct their efforts toward this species during spring and early summer.

In 1986, Baltimore City reached an agreement with Trout Unlimited to release a minimum of 11.5 cubic feet per second of cool water from the bottom of Prettyboy Reservoir. Since that time, an exceptional year-round trout fishery has developed downstream. Up to 250 pounds of reproducing trout (mostly brown trout) per acre of stream may be found in some areas between Prettyboy and Loch Raven reservoirs. This fishery is especially valuable because of excellent public access and the proximity of the fishery to metropolitan Baltimore. In addition to the trout fishery in the river's mainstem, a number of tributary streams harbor native brook trout populations. Fishing effort for this species is light. In tidal areas, recreational fishermen target largemouth bass, striped bass and channel catfish, but yellow perch, and white perch are also caught in substantial numbers. In recent years, yellow perch stocks have increased dramatically. As a

result, spring fishing for this species has once again become popular.



No commercial fishing occurs in the non-tidal portion of the basin, but a number of species are harvested during spring from the tidal portion of the river. In a peculiar twist of fate, gizzard shad, an abundant but inedible species, is harvested for sale to the Louisiana aquaculture industry—to lure unsuspecting crawfish from their ponds into traps from which they are transported to market. Some of the other fish species harvested from the tidal portion of the basin include striped bass, white perch, and channel catfish. The catfish are often sold alive to fee fishing ponds in the midwest.

CITIZEN INVOLVEMENT

During the last decade, an increasing number of concerned citizens have become involved in organizations and programs working to protect and restore Maryland's aquatic resources. Many such organizations focus their work on a particular river basin or stream. The Gunpowder Valley Conservancy has worked to preserve the rural character, history, and

environmental integrity of the Big and Little Gunpowder Falls watersheds since 1989. The Conservancy publishes a newsletter titled the *Gunpowder Valley Guardian*. Volunteer activities include watershed inventories, stream clean-ups, tree plantings, adopt-a-river programs, and land preservation activities (ACB 1996; Conklin 1997).

Maryland Save Our Streams (SOS) sponsors several activities in the Gunpowder River basin, including Adopt-a-Stream programs, watershed surveys, and storm drain stenciling. Through Project Heartbeat, SOS volunteers monitor stream quality using benthic macroinvertebrates in the Baltimore County portion of the basin. Benthic macroinvertebrates are sampled at about 50 stream sites in the basin every year. During 1997, 70 sites were sampled in the basin as a result of the Gunpowder Watershed Project, described on page 7. SOS volunteers also conduct physical habitat assessments at each stream site. Data from SOS stream monitoring are used by the Baltimore County Department of Environmental Protection and Resource Management for several watershed management programs (SOS 1994).

On the fly...

Two organizations are working to preserve trout waters and promote fly fishing in Maryland. Trout Unlimited is a national organization that publishes Trout Magazine and conducts activities including habitat improvements, water quality monitoring, riparian reforestation, and bank stabilization. Free State Fly Fishers, established in 1974, promotes flyfishing in Maryland through education and conservation (ACB 1996). For more information about these two trout-related organizations see Appendix A.

With involvement of local citizens, the Alliance for the Chesapeake Bay conducts riparian forest zone restoration projects at several stream sites in the Gunpowder River basin. After trees and other vegetation are planted in riparian zones, long term monitoring of stream and riparian zone quality is conducted to evaluate the effectiveness of buffer restoration (Page 1997).



Photo courtesy of Maryland Save Our Streams

The Baltimore County Forest Conservancy District Board, a volunteer organization supported in part by Baltimore County, works with the DNR Forest Service to educate property owners, students, and volunteers in the preparation and planting of trees in urban, riparian, and rural areas of Baltimore County (Conklin 1997). Current projects include the School Yard Reforestation and Wildlife Habitat Program, Greening Committees in local communities, educational programs for teachers, the Days Cove Environmental Center development project, and other activities that encourage the planting, appreciation, and care of trees. The program advocates forest stewardship and management planning in rural communities, cooperation with local landowners in the Rural Legacy and Agricultural Programs, and forest and buffer incentive programs. Information about the Board may be found in the newsletter, *Tree Talk*, published 3 times per year.

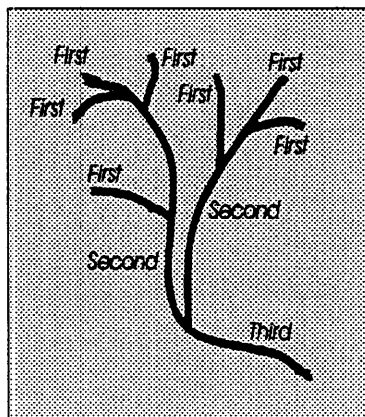
Since 1993, the Watershed Protection Coalition has worked to protect the Baltimore City-owned watersheds in the Gunpowder River basin (Prettyboy and Loch Raven) and to support responsible public policy for their long-term stewardship. The group publishes a periodic flyer and provides information on their activities to groups and individuals.

Information about these and other citizen, river, and watershed organizations can be found in ACB (1996). A list of organizations with opportunities for citizen involvement in water quality monitoring is found in Appendix A.

CHAPTER THREE

SURVEY DESIGN AND SAMPLING METHODS

This chapter briefly outlines the approach used to survey stream resources of the Gunpowder River basin during 1996. The design used for this assessment differs from other stream surveys that have been conducted in Maryland. Randomly-selected sampling sites for the MBSS on first, second, and third order streams (Strahler 1964) were chosen by computer rather than selected by the investigator. This approach allows estimates to be calculated for an array of ecological factors such as fish density and stream habitat condition. Non-randomly selected sites were also sampled to provide additional information on fish distributions. The random and non-random sites sampled in 1996 in the basin as part of the MBSS are shown in Figure 3.

**STREAM ORDER**

Stream order is a simple way to measure stream size. The smallest permanently flowing stream is termed first order, and the union of two first order streams creates a second order stream. A third order stream is formed where two second order streams join. Stream order is often related to watershed area.

Because most sites in the Gunpowder River basin were on private land, landowner permissions were sought for each randomly-selected MBSS site. This procedure required contact with property owners, usually by phone. Overall, 89% of the landowners contacted in the basin gave permission to have streams on their property sampled.

After landowner permissions were obtained, sampling sites were located with Global Positioning System (GPS) receivers, fish and benthic macroinvertebrates were collected, and physical habitat features were evaluated using methods patterned after EPA's Rapid Bioassessment Protocols (Plafkin *et al.* 1989). Water quality was sampled using protocols previously established for acid rain studies in Maryland. Because the primary purpose of the MBSS is to assess the effect of acid rain on Maryland streams and rivers, other important water quality measures such as phosphorus and turbidity were not measured.

Reptiles, amphibians, and mussels were also monitored on a presence/absence basis. All catchments draining to the MBSS

sampling sites were delineated and land use (MOP 1994) was estimated for each. Throughout all sampling and data management activities, an extensive Quality Control program was employed. Additional technical information about stream survey methods in the Gunpowder basin during 1996 and the survey results can be found in Appendix B of this report, Volstad *et al.* (1995), and Kazyak (1996).

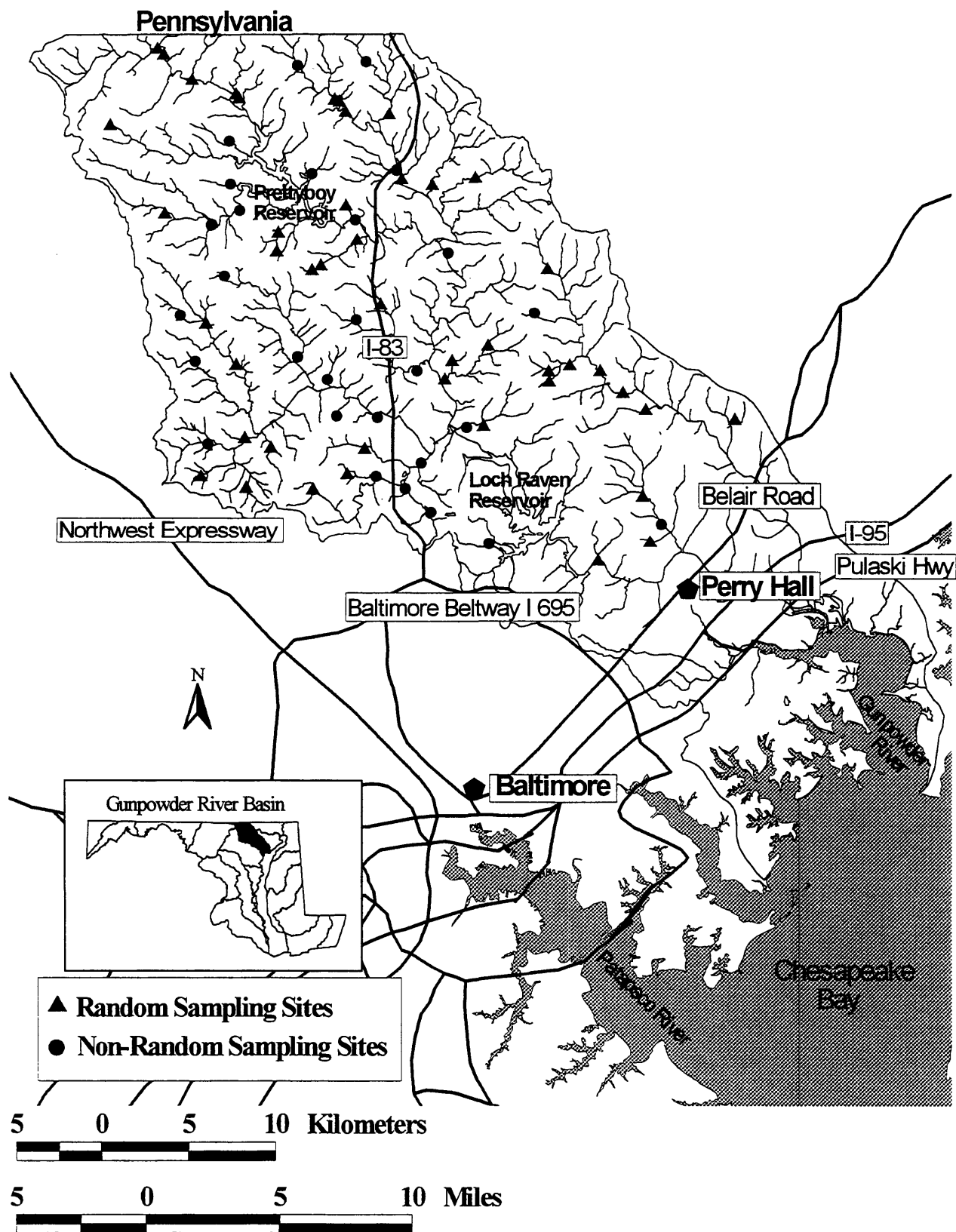


Figure 3. Locations of 1996 MBSS sampling sites in the Gunpowder River basin. Major highways, populations centers, and other features are shown for reference. Inset map shows the basin location within Maryland.

CHAPTER FOUR

CURRENT STATUS OF AQUATIC RESOURCES

This chapter uses 1996 Maryland Biological Stream Survey (MBSS) data from 45 randomly-selected and 32 non-randomly-selected (fish only) sampling sites in the Gunpowder River basin to describe the current status of non-tidal streams. It is important to note that because most sites were selected randomly, portions (such as the Coastal Plain) of the basin may have few or no sites. During the next round (2000 to 2002) of the Survey, DNR will address gaps in data from the current round (1995-1997) and will target certain streams for sampling.

GENERAL CHARACTERISTICS OF GUNPOWDER RIVER BASIN STREAMS

45 random stream sites were sampled in spring and summer 1996 in the Gunpowder River basin. Eighteen first order, 13 second order, and 14 third order streams were sampled.

All sampling sites were in the Piedmont Plateau (generally north and east of I-95), where streams tend to be of moderate gradient with riffles that aerate the water. Stream gradient ranged from 0.5% to 10%. A stream with a 10% gradient drops 10 m in elevation for every 100 m of stream channel length. Stream width varied from 1 m (a stream you could easily jump across) to 15 m (about as wide as a 3-lane highway). A map of the 1996 MBSS sites in the basin is shown in Figure 3. A list of the streams sampled is presented in Appendix C.



Photo by Niles Primrose

WATER QUALITY

Dissolved Oxygen

Dissolved oxygen (DO) is one of the most basic requirements of aquatic organisms, thus DO levels play an important role in shaping biological communities in streams. DO in streams may be low due to nutrient-rich runoff and groundwater inputs from urban and agricultural areas, oxygen demanding organic chemicals in point source discharges, or the breakdown of naturally-occurring organic material such as leaves. The State of Maryland has established a minimum surface water criterion of 5 milligrams per liter (mg/L) for DO. When DO is low (i.e., less than 5 mg/L), only those organisms adapted to low DO can persist. In the Piedmont Plateau, streams typically have riffles, where water bubbles over rocks. Riffles help to keep DO levels high by aerating the water. In the Coastal Plain area, most streams are gently sloping and have few riffles to aerate the water. As a result, increased oxygen demand in Coastal Plain streams from human sources, such as sewage, animal wastes, and fertilizers can have a greater impact on aquatic communities than occurs in higher gradient streams of the Piedmont area. It should be noted that during the MBSS, DO is measured only once during the day and that in heavily impacted streams, DO may drop severely during the early morning hours due to algal respiration.

No stream miles in the basin had DO levels below the state water quality criterion of 5 mg/L (COMAR 1995). This suggests that runoff of oxygen-demanding materials into basin streams does not produce widespread DO-related problems. However, the same runoff which enters these streams ultimately reaches Chesapeake Bay and may contribute to water quality problems there.

pH and Buffering Capacity

In 1996, all of the stream miles in the basin had pH values greater than 6, indicating that acidity is not a

Acidity is an important aspect of stream health. The balance between free hydrogen ions (which increase acidity) and negative ions (which decrease acidity) is measured as pH. The capacity of soil or water to absorb acids without changing the ion balance is known as its buffering capacity, measured as alkalinity or Acid Neutralizing Capacity (ANC). Streams with ANC less than 0 $\mu\text{eq/L}$ are acidic and very poorly buffered. Streams with baseflow ANC between 0 and 200 $\mu\text{eq/L}$ are only moderately buffered and may periodically have low pH levels during rain or snowmelt events. Those streams with ANC greater than 200 $\mu\text{eq/L}$ are well-buffered. Under acidic conditions, certain metals such as aluminum are dissolved into water and reach levels that can be lethal to aquatic organisms. Acidity in streams is affected by rain, snow, fog and atmospheric dust, geology and soil characteristics, and organic matter.

Acidification of streams can be either chronic (i.e., year-round) or episodic (seasonal or storm event-related), depending on the capacity of the stream to buffer acid inputs. Chronically acidified streams generally contain only those organisms highly tolerant of acid conditions. In contrast, streams which are only episodically acidified can and often do support less tolerant "invaders" from better buffered downstream areas during summer low flow periods.

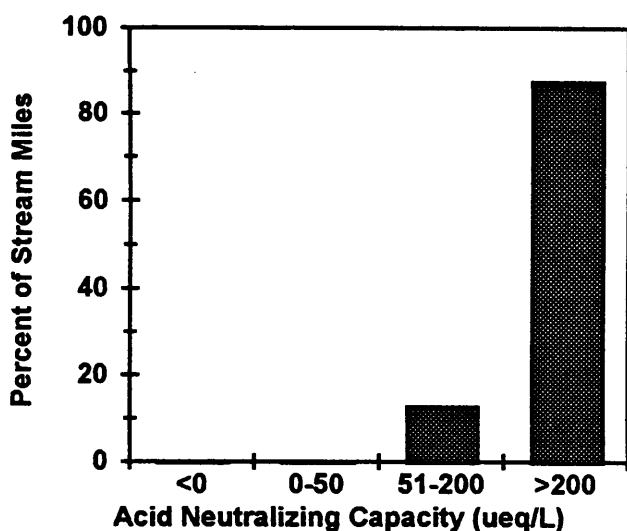


Figure 4. Acid Neutralizing Capacity (ANC) in non-tidal streams of the Gunpowder River basin (1996).

problem. Significant adverse impacts on aquatic life are known to occur for some species when pH values drop below 6, and for most species at pH less than 5.

None of the stream miles had acid neutralizing capacity (ANC) values less than 0 $\mu\text{eq/L}$, indicating none of the streams in the basin were chronically acidified (Figure 4). About 13% of the stream miles had (ANC) levels less than 200 $\mu\text{eq/L}$ and thus may be susceptible to periodic acidification. Streams with ANC greater than 200 $\mu\text{eq/L}$ are considered well-buffered and probably not susceptible to acid deposition impacts.

Nitrates and Dissolved Organic Carbon

Two important indicators of the sources of acidity in Maryland streams are nitrate and dissolved organic carbon (DOC).

- *An important source of nitrates in Maryland streams is deposition from the atmosphere. However, leaching into groundwater and direct runoff of fertilizers and animal wastes used on agricultural lands are other important sources of nitrates. Stream nitrate concentrations greater than 1 mg/L signify elevated nitrification (Morgan 1995).*
- *The primary source of DOC in streams is leachate from decaying leaves and other plant material that are natural sources of organic matter found within the stream drainage network itself, especially wetlands. DOC concentrations greater than 10 mg/L indicate that organic acids contribute significantly to overall acidity, but DOC levels between 5 and 10 mg/L also indicate that natural sources are contributing to overall acidity in a stream (Morgan 1995).*

All stream miles in the basin had nitrate values greater than 1 mg/L, indicating that excess nutrients are an environmental problem. Because these results represent primarily spring baseflow conditions, and by inference groundwater concentrations, reductions in nitrate loading in the basin may not be apparent for many years to decades until groundwater sources are purged

of their relatively high nitrogen levels, even if point and non-point sources of nitrates are reduced in surface waters.

Almost all (99%) stream miles in the basin had DOC levels less than 5 mg/L and no stream miles had DOC levels greater than 10 mg/L. This indicates that wetland areas are not a significant influence on stream water quality in the basin (Figure 5).

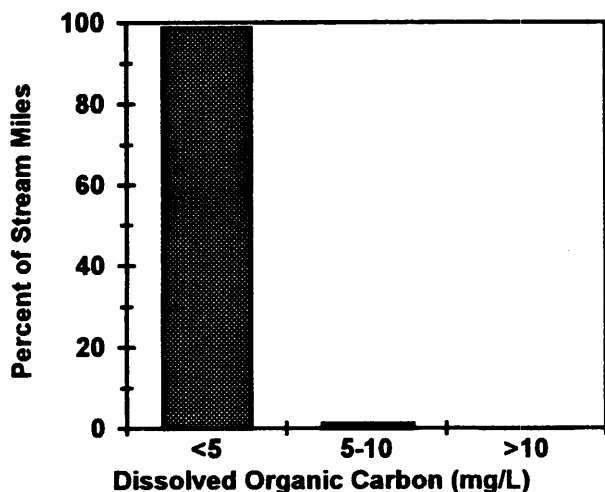


Figure 5. Dissolved Organic Carbon (DOC) in non-tidal streams of the Gunpowder River basin (1996).

PHYSICAL HABITAT

WHAT IS HABITAT?

The physical/chemical theater in which the ecological play takes place; it is a template for the biota, their interactions and their evolution (ITFM 1995).

Many physical habitat characteristics of streams are important determinants of ecosystem structure and function. Although a large number of physical habitat variables were measured by the MBSS, they can be grouped into four general categories: instream habitat, channel characteristics, riparian zone, and aesthetics/remoteness. Most variables are classified (in order of decreasing habitat quality) as good, fair, poor, or very poor. A description of selected MBSS physical habitat variables is included in Appendix D.

Instream Habitat

The complexity and stability of habitat in a stream typically has a strong relationship with abundance and diversity of biological communities that occur there. Important instream habitat characteristics include: 1) quality and composition of the stream bottom; 2) diversity of depths and flows; and 3) amount and quality of stable habitat for fish shelter and attachment sites for benthic macroinvertebrates.

Twenty-three percent of the stream miles in the basin were rated as either poor or very poor for instream habitat (Figure 6). Most instream habitat problems result from the removal or loss of woody debris from stream channels, increased sedimentation, and modification of stream channels due to increased runoff. All three impacts often occur when lands are developed for agricultural or urban uses.

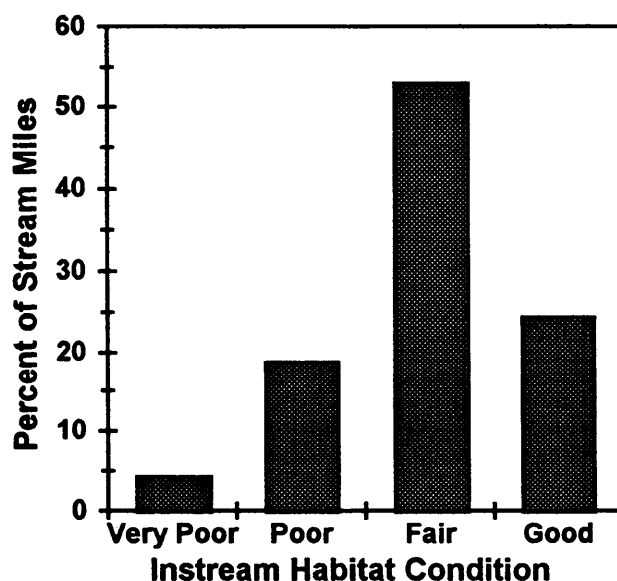


Figure 6. Instream habitat condition in non-tidal streams of the Gunpowder River basin (1996).

Increased sediment loads tend to reduce the complexity and stability of the stream bottom, resulting in loss of habitat for fish. Another common occurrence is the coating or burial of stones in riffle areas. Since many benthic macroinvertebrates such as mayflies and stoneflies use the spaces between rocks as living

quarters, high sediment loads reduce the amount of available habitat and reduce benthic macroinvertebrate diversity and abundance in streams. Fifty-five percent of the stream miles in the Gunpowder River basin were rated as either very poor or poor based on embeddedness, while only 12% were good (Figure 7).

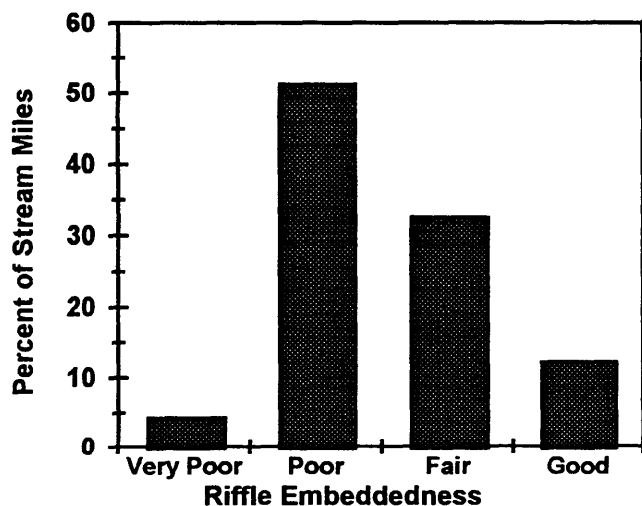


Figure 7. Riffle embeddedness in non-tidal streams of the Gunpowder River basin (1996).

Another impact to instream habitat quality may be a reduction in the abundance of wood (i.e., large woody debris such as logs, limbs, and rootwads) along stream banks and in stream channels. Wood in streams may greatly enhance habitat quality for both fish and benthic macroinvertebrates by providing a diverse array of shelter, depths, and velocities. Woody debris also traps and retains leaves, a vital food supply for many benthic macroinvertebrates. Undisturbed streams in naturally-forested areas generally contain a great deal of woody material. While very few stream sites in the basin contained no wood (2%), only 7% of the sites contained more than 1 rootwad or woody debris per 30 feet of stream channel (Figure 8). As a measure of comparison, the shape and stability of 80% or more of stream channels within old growth forests is often determined by the amount and placement of wood (Maser and Sedell 1994).

About 7% percent of all stream miles in the basin are artificially straightened and channelized. During channelization, trees in the riparian zone are often cut and woody debris is removed from the stream channel to allow for efficient movement of water away from

agricultural fields and housing developments. As a result, heavily-channelized streams are generally shallow, with little habitat for living resources. An added problem is reduced retention and rapid transport of nutrients into the Gunpowder River and eventually the Chesapeake Bay.

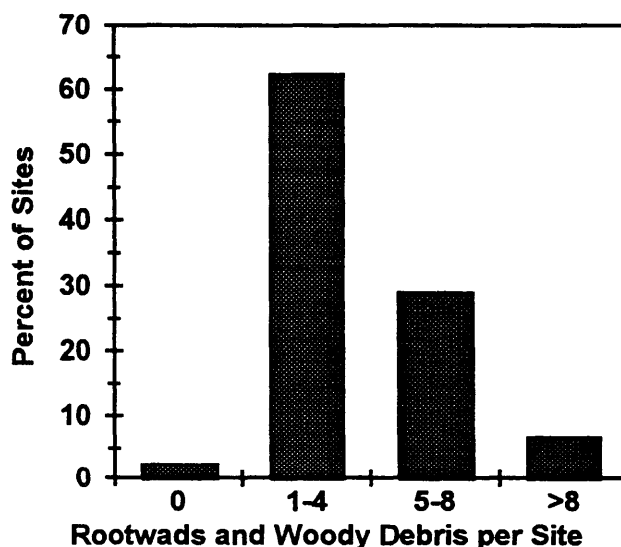


Figure 8. Percent of non-tidal stream sites in the Gunpowder River basin containing rootwads and woody debris (1996).

Another cause of the reduced abundance of woody debris and rootwads in the basin is related to prevailing forestry practices. In today's managed forests, trees are rarely allowed to achieve senescence (large age and natural death). Thus one of the vital and controlling elements of instream habitat (large dead trees and tree limbs) is largely prevented from entering the aquatic environment.

Channel Characteristics

Large-scale disturbance in the stream channel may result from watershed development or channel modification. Evidence of stream channel disturbance includes excessive bar formation, the presence of artificial structures (e.g., concrete armoring and rip-rap), channel dewatering for irrigation and other uses, and severe bank erosion.

As the landscape within the Gunpowder River basin was developed for agriculture and then (in many areas) urbanized, many miles of stream channels were

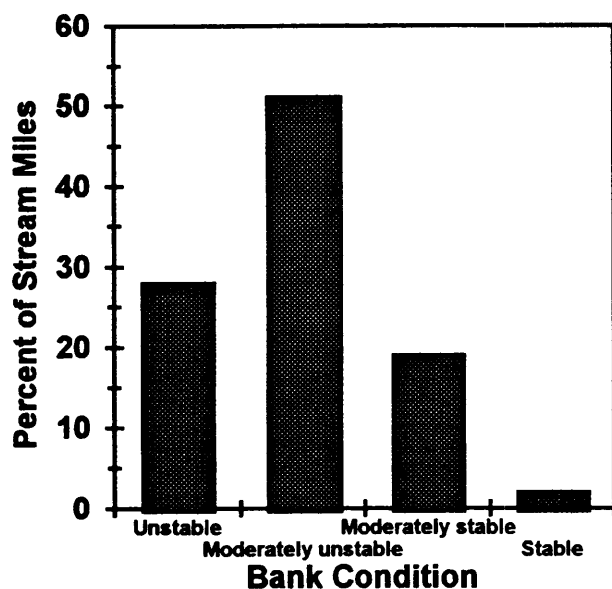


Figure 9. Percent of stream miles and associated stream bank conditions in non-tidal streams of the Gunpowder River basin (1996).

destabilized, resulting in highly eroded banks and sand/silt bars in slow moving areas. With increasing urbanization, channel conditions continue to change. In 1996, an estimated 79% of the stream miles in the basin had degraded bank conditions (unstable or moderately unstable banks). Bank erosion was severe in 28% of all stream miles and only about 2% of the stream miles had banks that were stable (Figure 9).

The instability of stream channels in the basin increases the nutrient and sediment loads transported to Chesapeake Bay.

Riparian Zone

The riparian zones of Gunpowder River basin streams were in fair condition (Figure 10). About one-half (52%) of all stream miles had vegetated riparian zone widths greater than 50 meters. Wide forest buffers were present in 47% of all stream miles, providing habitat for corridor-dependent species, leaf litter, and woody debris to stream channels. About fifteen percent of the stream miles in the basin

Riparian zones are the areas alongside streams, rivers, and other waterbodies. When these areas are vegetated, they play a vital role in structuring and maintaining physical habitat, energy flow and aquatic community composition. Vegetated buffers (trees, shrubs, and grasses) can decrease runoff and prevent particulate pollutants from entering streams (Plafkin et al. 1989). Trees and shrubs also provide energy inputs to the stream in the form of leaf litter and woody debris, stabilize stream channels, supply overhead and instream cover for fishes and other aquatic life, and moderate stream water temperature.

contained no vegetated buffers and thus were not protected against runoff.

The presence of trees in riparian zones is reflected in the amount of shading evident in the sampled streams. About one-half of all stream miles in the basin were well-shaded during summer 1996. Forest cover along streams greatly decreases exposure of the stream channel to direct sunlight and helps prevent warming of stream waters above their natural condition. Riparian forests also reduce nutrient exports to Chesapeake Bay.

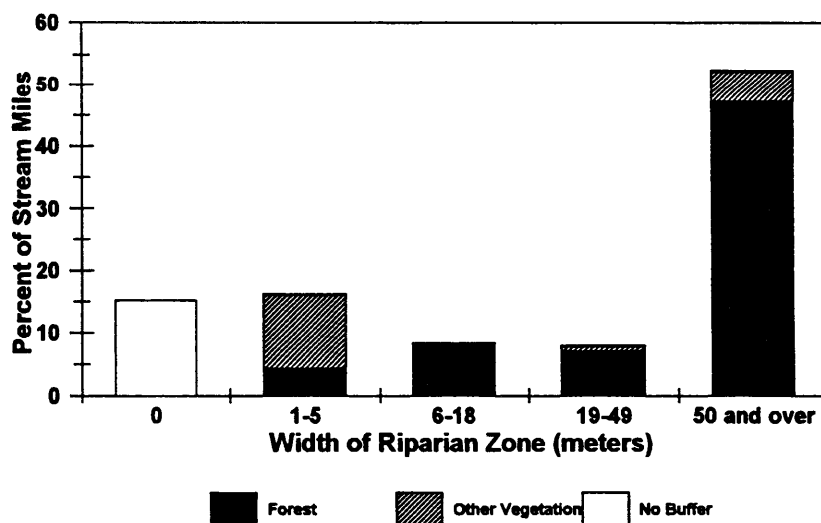


Figure 10. Riparian zone width and type in Gunpowder River basin streams, 1996. Other vegetation includes old field, mowed lawn, and tall grass.

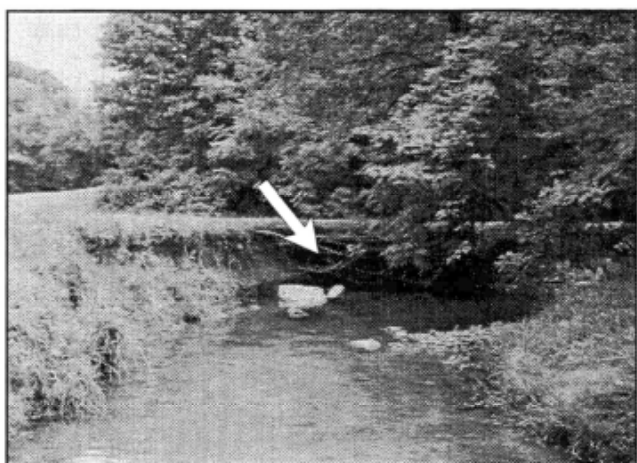


Photo by Niles Primrose

Trees along stream banks can help stabilize soils and prevent bank erosion. The arrow above shows a tree root stabilizing the bank of Goodwin Run, a stream in the lower part of the Gunpowder River basin. Much of the sediment flowing into the Chesapeake Bay comes from sediment eroding banks of small streams such as this.

Aesthetics/Remoteness

What is the worst stream pollution problem?

When asked this question, many people will respond with one word... "trash". Although trash in and along streams is unsightly and undesirable, it is often not the primary cause of stream degradation. However, it may be a good indicator of upstream watershed conditions. The more people living or working in a watershed, the more likely trash will end up in the stream draining the watershed. Some groups conducting stream monitoring programs are developing indices based on the number of articles of trash (such as shopping carts) at a stream site. Quantifying stream characteristics like the presence of trash will help us gauge our success in stormwater management, public education and even recycling.

Most stream miles in the Gunpowder River basin were rated as either fair (45%) or good (43%) based on the amount of human refuse present (Figure 11). Over one-half (53%) of stream miles in the basin had either a moderately wild or wild character. Only 9% were immediately adjacent to roads.

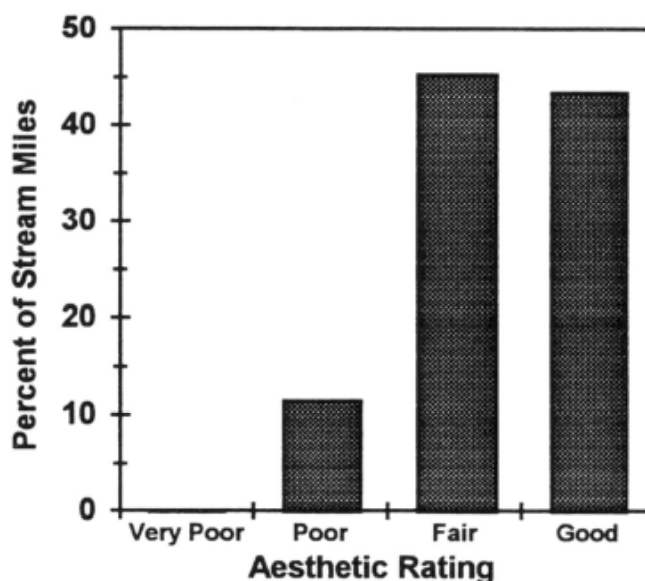


Figure 11. Aesthetic rating for non-tidal streams of the Gunpowder River basin (1996).

FISHERY RESOURCES

General Description

A total of 40 fish species representing 11 families were collected in the Gunpowder River basin in first, second, and third order streams during 1996 (Table 1). Fish sampling was conducted at all 45 random sites and at 32 non-random (presence/absence) sites. Fish were present at all but one of the 77 total sites sampled. The total abundance of fish in first through third order streams was about 3,200,000. Basin-wide estimates of abundance for individual species ranged from less than 100 rainbow trout to more than 900,000 blacknose dace. The 6 most abundant species in the basin were blacknose dace, rosyside dace, creek chub, longnose dace, mottled sculpin, and tessellated darter (Figure 12). Consistent with the presence of mostly cool water fish habitat in the Gunpowder River basin, the minnow family (*Cyprinidae*) had the greatest number of fish species (15), followed by the sunfish family (*Centrarchidae*) with 9 species. The catfish family (*Ictaluridae*), trout family (*Salmonidae*), and perch family (*Percidae*) were represented with 3 species each. The remaining 6 families were represented by only 1 or 2 species.

Table 1. Estimated total abundance and percentage occurrence of fish species collected in the Gunpowder River basin in 1996 (first, second and third order non-tidal streams combined), and a comparison of fish species taken at random versus non-random sites.

Family Common Name (Scientific name)	Sampling Method ¹	Percentage Occurrence	Population Estimate ^{2,3}	Standard Error
Petromyzontidae				
Sea Lamprey (<i>Petromyzon marinus</i>)	R	2.6	1,224	796
Anguillidae				
American Eel (<i>Anguilla rostrata</i>)	B	27.3	56,518	18,616
Cyprinidae				
Blacknose Dace (<i>Rhinichthys atratulus</i>)	B	93.5	986,393	127,282
Bluntnose Minnow (<i>Pimephales notatus</i>)	B	23.4	25,859	21,895
Central Stoneroller (<i>Campostoma anomalum</i>)	B	24.7	18,207	9,380
Common Shiner (<i>Luxilus cornutus</i>)	B	42.9	63,234	10,309
Creek Chub (<i>Semotilus atromaculatus</i>)	B	89.6	406,574	73,665
Cutlips Minnow (<i>Exoglossum maxillingua</i>)	B	45.5	116,066	43,078
Fallfish (<i>Semotilus corporalis</i>)	B	2.6	123	113
Fathead Minnow (<i>Pimephales promelas</i>)	R	1.3	123	120
Longnose Dace (<i>Rhinichthys cataractae</i>)	B	75.3	322,002	333,576
River Chub (<i>Nocomis micropogon</i>)	B	36.4	48,284	12,588
Rosyside Dace (<i>Clinostomus funduloides</i>)	B	68.8	443,753	115,035
Satinfin Shiner (<i>Notropis analostana</i>)	B	7.8	5,313	3,012
Silverjaw Minnow (<i>Notropis buccatus</i>)	N	2.6		
Spottail Shiner (<i>Notropis hudsonius</i>)	N	1.3		
Swallowtail Shiner (<i>Notropis procne</i>)	R	7.8	10,939	5,608
Catostomidae				
Northern Hogsucker (<i>Hypentelium nigricans</i>)	B	45.5	45,314	16,257
White Sucker (<i>Catostomus commersoni</i>)	B	74.0	107,991	18,359
Ictaluridae				
Brown Bullhead (<i>Ameiurus nebulosus</i>)	N	3.9		
Margined Madtom (<i>Noturus insignis</i>)	B	32.5	72,959	24,662
Yellow Bullhead (<i>Ameiurus natalis</i>)	B	7.8	1,733	1,403
Salmonidae				
Brook Trout (<i>Salvelinus fontinalis</i>)	B	22.1	66,274	28,518
Brown Trout (<i>Salmo trutta</i>)	B	42.8	55,026	21,539
Rainbow Trout (<i>Oncorhynchus mykiss</i>)	B	5.2	65	73
Fundulidae				
Mummichog (<i>Fundulus heteroclitus</i>)	N	2.6		
Poeciliidae				
Mosquitofish (<i>Gambusia holbrooki</i>)	N	2.6		
Cottidae				
Mottled Sculpin (<i>Cottus bairdi</i>)	B	23.4	175,352	103,635
Centrarchidae				
Lepomis Hybrid	R	1.3	123	120
Bluegill (<i>Lepomis macrochirus</i>)	B	36.4	18,873	7,055
Green Sunfish (<i>Lepomis cyanellus</i>)	B	15.6	1,664	788
Largemouth Bass (<i>Micropterus salmoides</i>)	B	7.8	612	400
Longear Sunfish (<i>Lepomis megalotis</i>)	R	1.3	123	123
Pumpkinseed (<i>Lepomis gibbosus</i>)	N	6.5		
Redbreast Sunfish (<i>Lepomis auritus</i>)	B	9.1	3,211	1,171
Rock Bass (<i>Ambloplites rupestris</i>)	R	1.3	66	66
Smallmouth Bass (<i>Micropterus dolomieu</i>)	B	9.1	1,093	796
Percidae				
Fantail Darter (<i>Etheostoma flabellare</i>)	B	13.0	15,496	15,049
Shield Darter (<i>Percina peltata</i>)	B	5.2	1,612	826
Tessellated Darter (<i>Etheostoma olmstedii</i>)	B	59.7	118,222	28,595
Total Abundance for all Fish Species^{2,3}			3,190,423	441,724

¹ R indicates species was collected from only random sites, N indicates species was collected from only non-random sites, and no population estimates could be calculated, B indicates species was collected from both random and non-random sites.

² Total abundance (number per basin) adjusted for capture efficiency (Heimbuch, et al. 1997).

³ Non-random site information was not used in calculating population estimates.

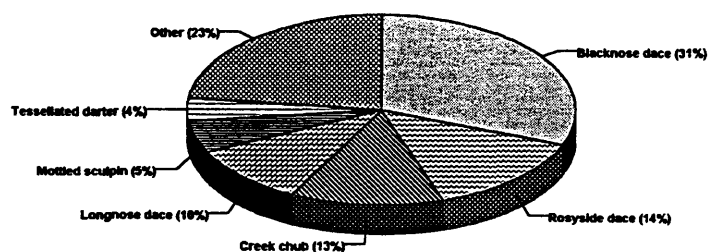
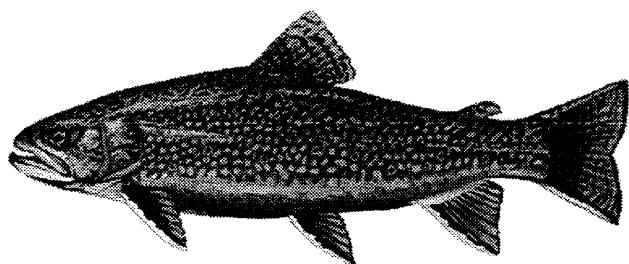


Figure 12. Relative abundance of the six most abundant fish species in non-tidal streams of the Gunpowder River basin (1996 random samples only).

Gamefish

Five species of gamefish were collected in the basin. Brook trout were the most abundant gamefish collected, with a density of 142 per stream mile. The basin-wide abundance of brook trout was about 66,200 individuals. Almost 15% of the brook trout collected were of harvestable size (greater than 6 inches). The density of brown trout, the next most abundant gamefish collected, was 118 per stream mile. This species had a basin-wide abundance of about 55,000 individuals. Over 25% of those individuals were of harvestable size (greater than 6 inches). Densities of largemouth and smallmouth bass were more than 2 and 1 per stream mile, respectively, with basin-wide abundances at about 1,000 and 600 individuals, respectively. None of the largemouth bass or smallmouth bass sampled in the basin were of legal size (greater than 12 inches). Rainbow trout were the least abundant gamefish collected, with a total abundance of 65 individuals. All of the rainbow trout collected were larger than 6 inches and were probably stocked in spring 1996.



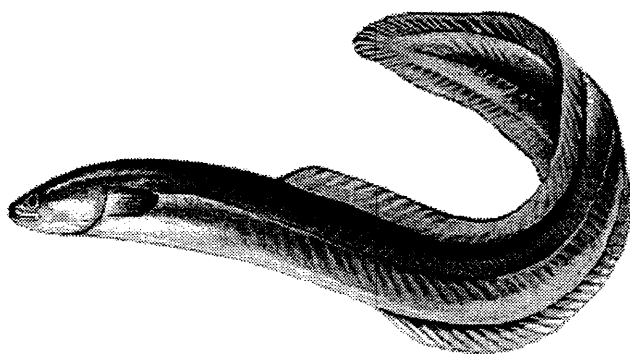
Brook trout, Maryland's only native trout, were found at 22% of all sites sampled in the Gunpowder River basin. "Brookies" were found most often in first order streams.

Rare and Uncommon Species

None of the fish species collected during 1996 are listed as threatened, rare, or endangered by either DNR or the U.S. Fish and Wildlife Service (DNR 1994).

Migratory Species

Only two species of migratory fish, the catadromous American eel and the anadromous sea lamprey, were collected in the Gunpowder River basin in 1996. Abundance and density were highest for American eel (about 56,000 individuals; 120 per stream mile) and lowest for sea lamprey (about 1,200 individuals; about 3 per stream mile). However, because MBSS sampling was conducted from June-September, well after the spawning period for anadromous and semi-anadromous fish, few adults of such species would be expected in the sampled streams.



The basinwide density estimate for American eel was 120 per stream mile.

One factor that limits the number of migratory fish within a basin is migration barriers such as dams and culverts. The Gunpowder River basin contains 23 known barriers, and most of the stream miles in the basin are upstream from at least 1 migration barrier. Although American eels can climb over many barriers that are impassable to other migratory fish, the majority of migratory fish most likely use the rivers and tributaries downstream of the lowest migration barrier within the basin and are prevented from moving farther upstream into smaller streams.

Stream Quality Based on an Index of Biotic Integrity

DNR recently developed a provisional Index of Biotic Integrity (IBI) for non-tidal stream fish communities (Roth et al. 1997) that is an effective tool for evaluating ecological conditions in streams. Using this IBI, various characteristics of the fish community are compared to results from high quality streams and scored. The summary score is then used to assess ecological conditions of streams in the basin as good, fair, poor, or very poor. Because DNR's fish IBI has not yet been fully tested and verified, the results in this section are preliminary and subject to change.

Based on DNR's fish Index of Biotic Integrity (IBI), about 19% of the stream miles in the basin were in good condition, about 36% of the stream miles were in fair condition, and about 13% of the stream miles were in poor condition (Figures 13 and 14). One-third of the stream miles could not be rated because fish IBIs for very small streams have not yet been developed by DNR.

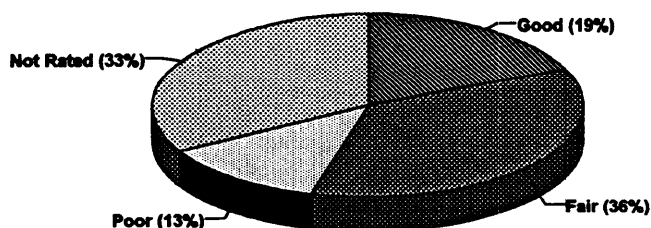


Figure 13. Stream quality in the Gunpowder River basin during 1996 based on the fish Index of Biotic Integrity (IBI). IBIs were not calculated for sites with catchment areas less than 300 acres ("Not Rated" category).

Prior to human settlement, small streams in the Gunpowder River basin were likely dominated by brook trout and several other fish species adapted to

coldwater conditions. With forest clearing and other human alterations of the landscape, summer stream temperatures increased along with nutrient levels. As a result, brook trout populations declined. However, the total abundance of other fish increased and several fish species were able to prosper in the now impaired habitat. Because DNR's IBI rates streams with high abundance and diversity more favorably than streams with fewer species and numbers of fish, the current approach may incorrectly characterize some sites. Like some other states with fish IBIs (e.g., Ohio and Wisconsin), DNR is working to develop and apply a separate IBI for fish communities in coldwater streams.

Why were a few sites rated as poor?

Three streams sampled in the Gunpowder River basin were rated poor based on their fish IBI (Figure 14). Baismans Run and Bush Cabin Run are first order streams that support brook trout (Appendix E, Figure E-23). Because these streams contained fewer species and a lower abundance of fish than many other streams in the state, the provisional IBI rated them as poor, even though both streams had good physical habitat and wide forested riparian zones. However Councilmans Run, a first order stream that also had few fish species, had poor physical habitat and was surrounded by cropland with a very narrow vegetated riparian zone. All these factors probably adversely affected the fish communities.

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates, or more simply "benthos", are animals without backbones that are larger than 0.5 millimeter (the size of a pencil dot). These animals live on rocks, logs, sediment, debris, and aquatic plants during some period in their life. The benthos include crustaceans, such as crayfish; mollusks, such as clams and snails; aquatic worms; and the immature forms of aquatic insects such as stonefly and mayfly nymphs.

There are about 123 families of stream-dwelling benthic macroinvertebrates in Maryland. Of these, 68 families were found in the Gunpowder River basin. Dominant types included non-biting midges, mayflies and amphipod crustaceans. A list of benthic

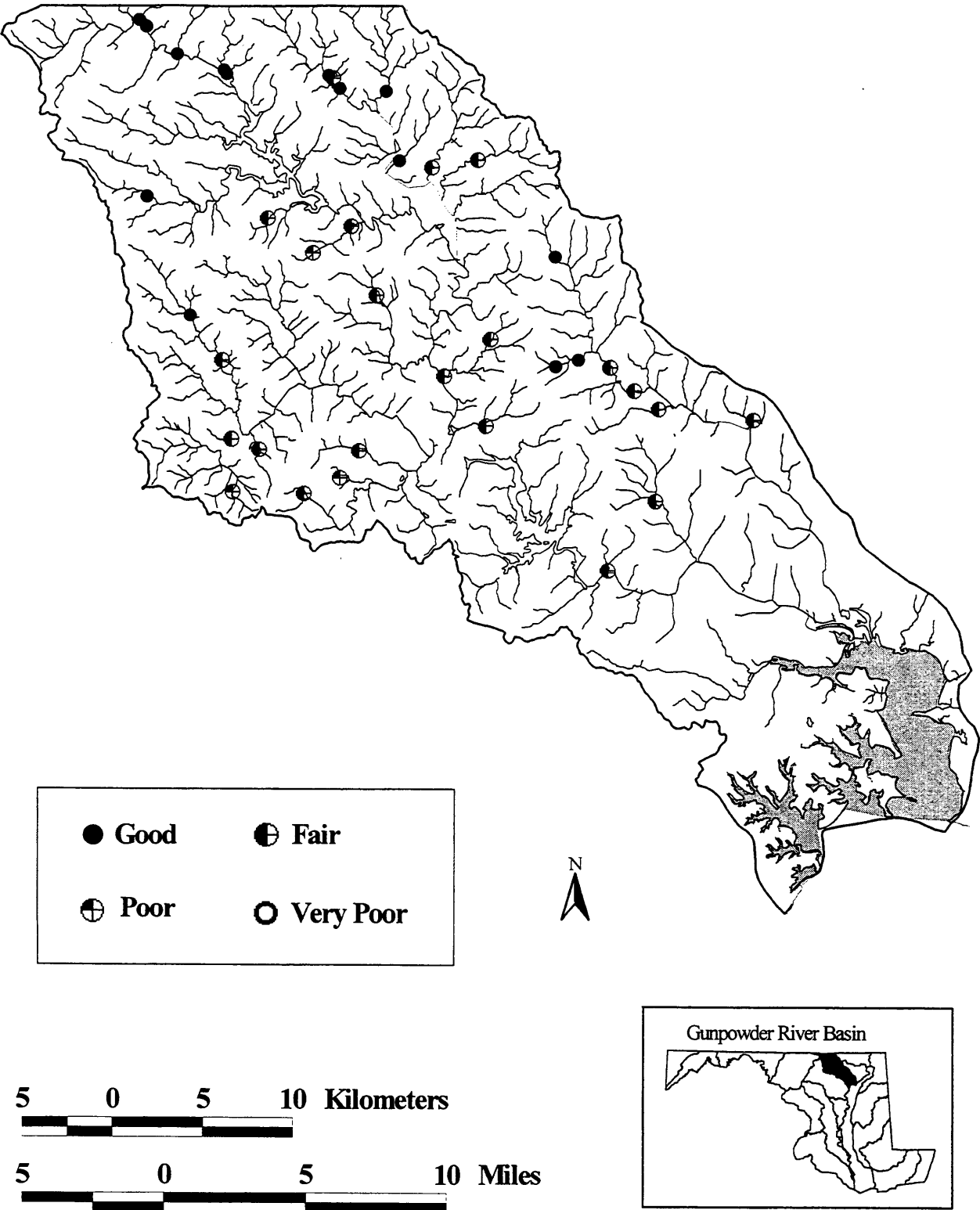


Figure 14. Non-tidal ecological conditions in the Gunpowder River basin based on the provisional fish Index of Biotic Integrity (IBI). IBIs were calculated only for random sites (drainage area greater than 300 acres), shown here.

Benthic Macroinvertebrates—good indicators of stream quality.

- *Unlike fish, benthos are fairly immobile, so they are less able to escape the effects of sediment and other pollutants that diminish water quality. Therefore, benthos can give us reliable information on water and habitat quality in streams.*
- *Benthos represent an extremely diverse group of aquatic animals, and the large number of species possess a wide range of responses to stressors such as organic and toxic pollutants and sediment.*
- *Many benthos are long-lived, allowing detection of past pollution events such as pesticide spills and illegal dumping.*

families collected in the Gunpowder River basin is found in Appendix F.

There are several benthic community measures used to evaluate stream quality. One commonly used measure is the Hilsenhoff Biotic Index, or HBI (WDNR 1977). This index uses pollution tolerance values assigned to individual families of benthic macroinvertebrates. The HBI score for each sample site may range from 1 to 5 and generally increases with greater proportions of pollution-tolerant organisms; thus the index is expected to decrease with increased stream quality.

In the Gunpowder River basin, the HBI ranged from 1.3 (good) to 3.3 (fair) among all sites (Figure 15). Nearly two-thirds of the stream miles were assessed as good, while the remaining one-third of the stream miles were assessed as fair. No stream miles were assessed as poor. It is important to note that the benthic macroinvertebrate tolerance values used to calculate HBI scores are largely based on best professional judgement. DNR is currently developing benthic community indices of biological integrity (IBIs), like the fish IBI described earlier, to rate the quality of non-tidal streams throughout Maryland. The HBI is just one of many metrics being tested for this composite index.

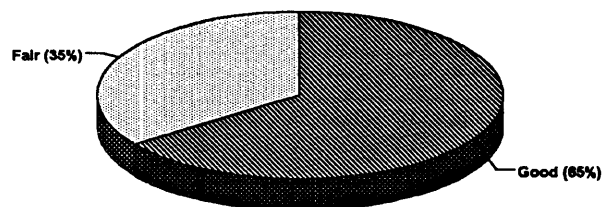
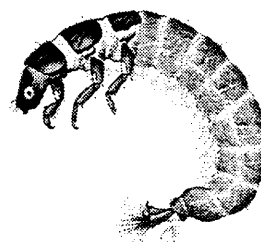
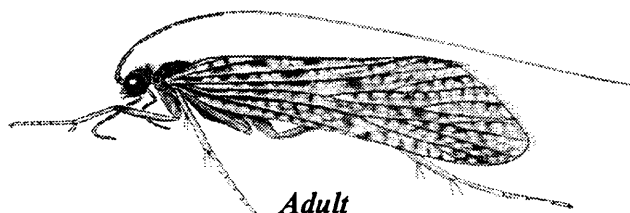


Figure 15. Stream quality in the Gunpowder River basin (1996) based on the Hilsenhoff Biotic Index. Possible ratings were Good, Fair, or Poor.



Larva



Adult

Caddisflies of the aquatic insect family Hydropsychidae spin nets of silk to capture bits of food flowing in the water. Although most caddisflies are considered pollution-sensitive, members of this family can tolerate somewhat polluted water. These insects were found at 83% of first order stream sites and all second and third order sites in the Gunpowder River basin in 1996.

FRESHWATER MUSSELS

Freshwater mussels were collected at only 2 of the 45 random stream sites sampled in the Gunpowder basin: Asiatic clam (*Corbicula fluminea*) and eastern elliptio

(*Elliptio complanata*). Eastern elliptio occurred at both sites, while the introduced Asiatic clam was only found at one site. In a recent field survey of the Gunpowder basin, eastern floater (*Pyganodon cataracta*), eastern lampmussel (*Lampsilis radiata*), and paper pondshell (*Utterbackia imbecillis*) were all collected in Loch Raven Reservoir (Motivans 1997). None of these species were collected during 1996 MBSS sampling.

Mussel species diversity in streams is often positively correlated with stream order (Strayer 1983; Watters 1993). In the Gunpowder basin in 1996, mussels were only found at third order streams.

REPTILES AND AMPHIBIANS

Table 2. List of herpetofauna observed in the Gunpowder River basin in 1996.

Frogs and Toads

American toad
Green frog
Bullfrog
Pickerel frog
Wood frog

Turtles

Common snapping turtle

Salamanders

Longtail salamander
Northern dusky salamander
Northern two-lined salamander
Red salamander

Snakes

Northern ringneck snake
Northern water snake
Northern copperhead

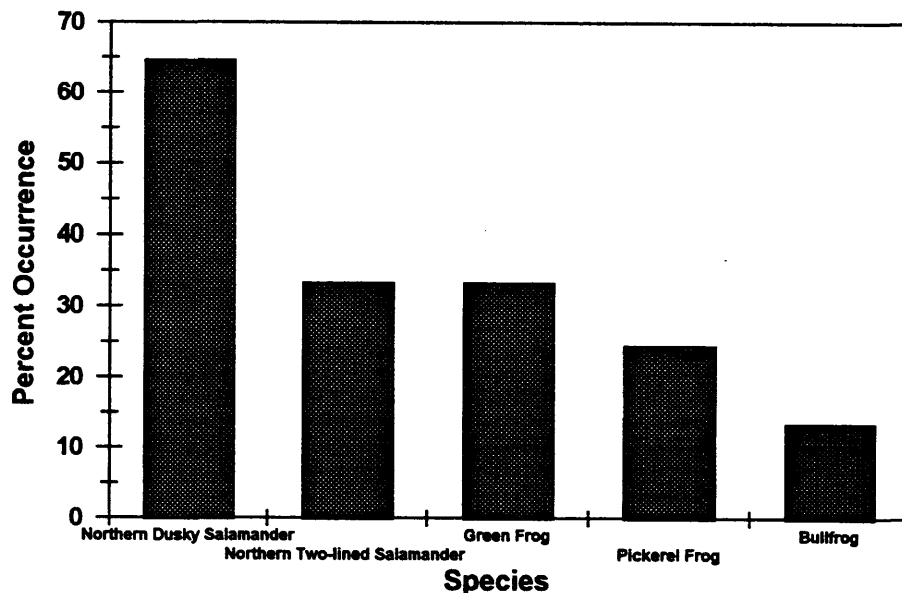


Figure 16. Percent occurrence of the 5 most commonly-observed amphibians and reptiles at streams in the Gunpowder River basin in 1996.

Reptiles and amphibians were found at almost all (91%) of the stream sites sampled in the Gunpowder River basin in 1996. Five frog, 4 salamander, 3 snake, and 1 turtle species were observed (Table 2). Northern dusky and northern two-lined salamanders, green frogs, and pickerel frogs were the most common species, occurring at 64%, 33%, 33%, and 24% of the sites, respectively (Figure 16).



Bullfrog

SUMMARY OF STREAM RESOURCE CONDITIONS

Results of the 1996 MBSS show that overall water quality conditions in Gunpowder River basin streams is good. These findings support the results reported in DNR (1996). There are few, if any, streams in the basin impaired due to low dissolved oxygen or acidification, and most streams in the basin are well-buffered against acidification. However, elevated nitrate levels (greater than 1 mg/L) were evident in all stream miles in the basin. Although urban runoff, atmospheric deposition, and point source discharges are sources of excess nitrate to surface waters, agricultural lands are likely the most important source of nitrate in streams in the basin (Figure 17). Stream nitrate concentrations increased as the percentage of agricultural land use in the catchments draining to MBSS sampling sites increased. Residential septic systems may be another source of groundwater associated nitrate to streams in the basin.

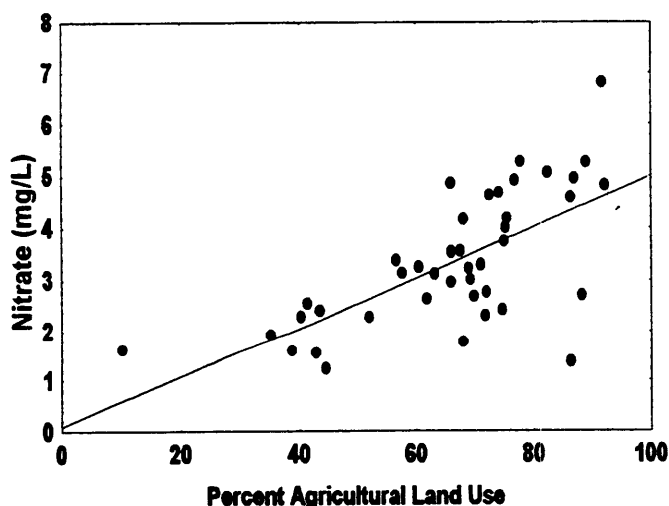


Figure 17. Agricultural land use and nitrate concentration at MBSS stream sites sampled in the Gunpowder river basin (1996).

Although water quality in the basin appeared to be good, about one-fourth of the stream miles had either poor or very poor instream habitat. Causes for degraded instream habitats include destruction of vegetated riparian corridors, channelization, excessive siltation, and groundwater withdrawal. Many streams have unstable banks. Sediments deposited in streams create embedded

riffles, reducing habitat for many benthic macroinvertebrates and fish species that need clean streambeds for spawning. Sediments from eroding stream banks are also a potential source of sediments in Chesapeake Bay

Fish species richness was moderately high (40 species in 11 families) and five species of gamefish were collected. However, the fish community was numerically dominated by pollution-tolerant blacknose dace. American eel and sea lamprey were the only two migratory fish collected in the basin, with American eel being the most abundant of the two species. There are 23 known barriers to migration in the basin (Figure 18) which could restrict upstream movement of most species (Leasner 1997).

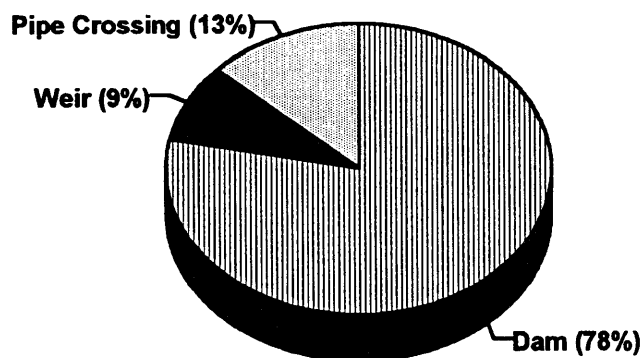


Figure 18. Barriers to fish migration in the Gunpowder River basin.

Most of the fish species in streams of the Gunpowder River basin are fairly pollution tolerant. Possible sources of such pollution include nutrient enrichment from agricultural and urban runoff, and the modification of physical habitat and water quality through channelization. Almost 25% of the fish species observed in 1996, including fathead minnow, brown trout, rainbow trout, rock bass, bluegill, green sunfish, longear sunfish, smallmouth bass, and largemouth bass are not native to the Chesapeake Bay drainage, although they are naturalized in Maryland. Unfortunately, there is little

historical information about fish communities in non-tidal streams of the Gunpowder River basin, so it is difficult to determine how the distribution and abundance of these and other species have changed over time. The 1996 MBSS results establish a benchmark of current fish species composition, distribution and abundance that can be used to track future changes.

Based on the fish IBI, slightly over half (55%) of the stream miles in the basin were categorized as either good or fair, and the rest were poor. No stream miles were categorized as very poor. Benthic macroinvertebrate community analyses suggest that there are more good stream miles in the basin than indicated by the fish IBI. The benthic indicator used in this report (Hilsenhoff's HBI) was designed to detect organic loading in streams; thus differences in findings between the two measures are not contradictory. Further refinement of both fish and benthic macroinvertebrate indicators will enhance our ability to evaluate specific impacts to non-tidal streams.

The amount of precipitation falling onto a river basin may be an important factor in shaping biological communities of streams. Dry, low flow periods are often considered most stressful for stream life due to higher water temperatures, reduction in the amount of available habitat, and less dilution of pollutants. In addition, heavy rainfall and high flows may result in large scale changes in physical habitat, temporarily lethal water quality conditions to some organisms, and transport of aquatic animals to less favorable habitats.

In 1996, total rainfall in the Gunpowder River basin was about 38 percent higher than average (Figure 19)(NOAA 1997). Only 3 months—February, June, and August—had below average rainfall. January, July, and December were the wettest months (greater than 67%

above average). An intense snowmelt/rainfall event during January 1996 may have caused significant stress to stream biota. Frequent storms during the MBSS spring sampling period and most of the summer sampling period could also have caused flow related habitat impacts such as increased scour and sediment deposition, resulting in decreased abundance of fish and benthic macroinvertebrates relative to drier periods. Also, high nutrient (and other pollutant) concentrations could result from runoff from urban and agricultural lands during wet periods. However, without long-term data on rainfall, flow, and stream ecological conditions, it is difficult to determine relationships among these environmental factors and stream quality. When the MBSS is repeated in future years, more light will be shed on this important subject.

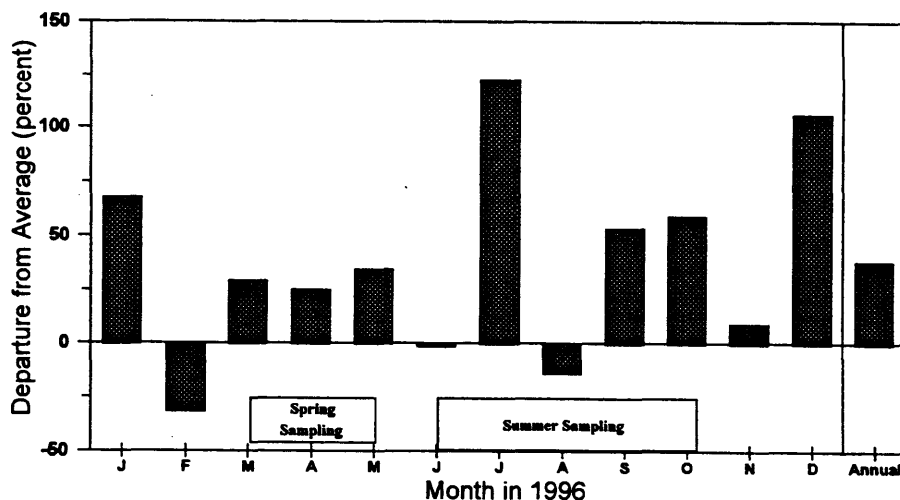
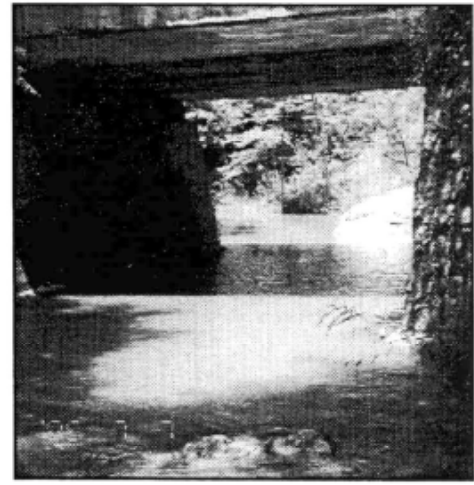
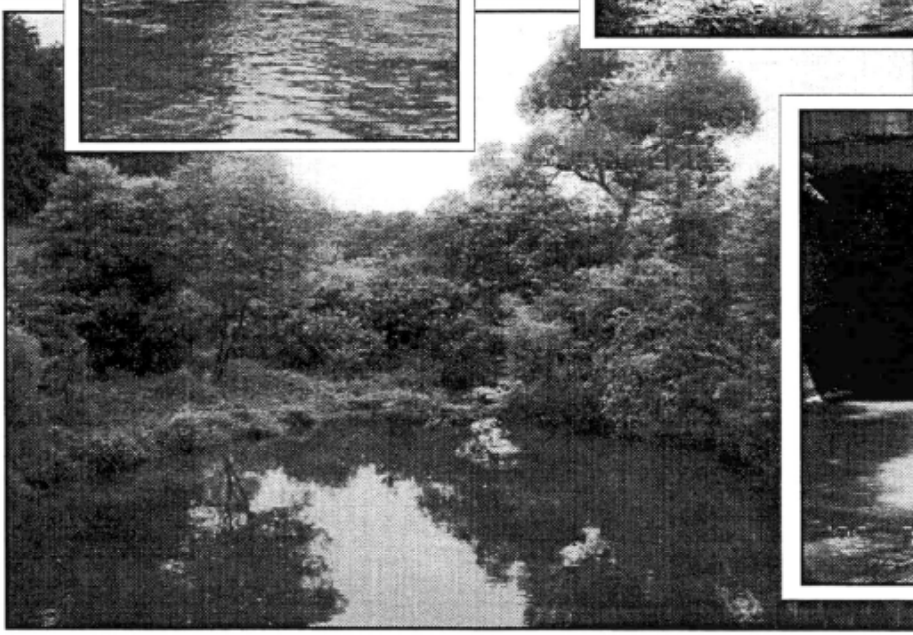
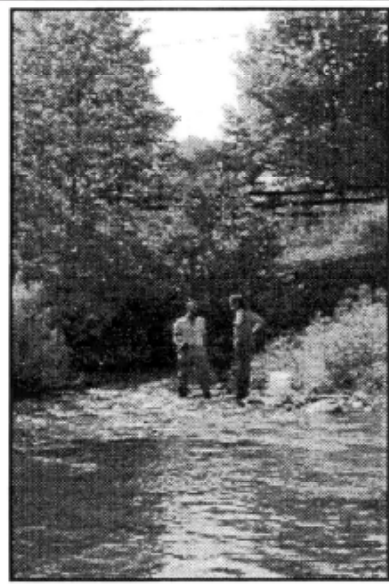


Figure 19. Monthly rainfall in the Gunpowder River basin (measured at Aberdeen) in 1996. Bars indicate the departure, as percent, from average monthly rainfall amounts for the period 1961-1990. Annual rainfall departure is shown at the right. The spring and summer MBSS sampling periods are also shown.

Given the level and types of stream impacts noted in 1996 and the projected changes in land use, human population size and water demands in the Gunpowder River basin, the biological communities and other ecological attributes of streams in the basin will likely become more degraded in years to come. Comprehensive implementation of best management practices (BMPs), such as riparian zone protection and reforestation, may partially offset these impacts. It is important to note that BMPs may reduce, but do not eliminate, the ecological impacts of human disturbance.

This report clearly demonstrates that valuable stream resources still exist in the Gunpowder River basin. However, in many ways, the basin still suffers from mistakes of the past. The entire basin has been logged, including riparian zones. As a result, unstable stream channels are common, physical habitat is greatly reduced, and even forested streams now carry elevated sediment loads. In addition, a network of dams and other migration barriers excludes many fish species from usable stream habitat. In more urbanized areas of the basin, large volumes of water flush directly into

streams during storms and baseflows are reduced to a trickle ring dry periods. These extreme fluctuations in flow create conditions that only the hardiest of aquatic animals can tolerate. All of these problems can be lessened or eliminated, but great cost is typically involved. Over time, we must work to restore conditions in the Gunpowder River basin for future generations. At the same time, however, we also need to make a concerted effort to protect and enhance the remaining high quality resources in the basin and elsewhere in Maryland. Only in this way can we learn to exist in a sustainable manner.



ALL PHOTOS NILES PRIMROSE

REFERENCES

- ACB (Alliance for the Chesapeake Bay). 1987. Fact Sheet on the Gunpowder River Basin. Baltimore, Maryland.
- ACB (Alliance for the Chesapeake Bay). 1996. Watershed Directory; 1996 Edition. A guide to citizen, river, and watershed organizations working in the Chesapeake Bay watershed. Towson, Maryland.
- Brush, G. S., C. Link, and J. Smith. 1977. The natural forests of Maryland: an explanation of the vegetation map of Maryland. Prepared by Department of Geography and Environmental Engineering, Johns Hopkins University for Maryland Power Plant Siting Program, Maryland Department of Natural Resources, Annapolis, Maryland.
- COMAR (Code of Maryland Regulations). 1995. Water Quality. Maryland Department of the Environment. Baltimore, Maryland.
- Conklin, C. 1997. Personal communication. Gunpowder Valley Conservancy. Glen Arm, Maryland.
- Department of Natural Resources (DNR). 1983. Gunpowder Falls State Park. Master Plan. Baltimore and Harford County Maryland. Maryland Department of Natural Resources. Annapolis, Maryland.
- DNR (Maryland Department of Natural Resources). 1985. Maryland Rivers Study; Executive Summary. Wild and Scenic Rivers Program. Annapolis, Maryland.
- DNR (Maryland Department of Natural Resources). 1994. Rare, threatened, and endangered animals of Maryland. Maryland Natural Heritage Program. Annapolis, Maryland.
- DNR (Maryland Department of Natural Resources). 1996a. Maryland water quality inventory: 1993-1995. Resource Assessment Service. Annapolis, Maryland.
- DNR (Maryland Department of Natural Resources). 1996b. Guide for cruising Maryland waters. Licensing and Registration Services, Annapolis, Maryland.
- DNR (Maryland Department of Natural Resources). 1997a. Watershed economic and environmental database. Chesapeake and Coastal Watershed Service. Annapolis, Maryland.
- DNR (Maryland Department of Natural Resources). 1997b. Maryland Tributary Strategies. Technical appendix for the Upper Western Shore Tributary Team basin (DRAFT). Resource Assessment Service. Annapolis, Maryland.
- DPW (Department of Public Works). 1981. The story of Baltimore's water supply. City of Baltimore. Bureau of Water and Waste Water. Baltimore, Maryland.
- EPA (U. S. Environmental Protection Agency). 1992. Submerged aquatic vegetation habitat requirements and restoration targets: a technical synthesis. Chesapeake Bay Program CBP/TRS 83/92. Annapolis, Maryland.
- Frieswyk, T.S. and D.M. DiGiovanni. 1988. Forest statistics for Maryland: 1976 and 1986. Resource Bulletin NE-107. USDA Forest Service, Northeastern Forest Experiment Station.
- Gertler, E. 1983. Maryland and Delaware canoe trails. Seneca Press, Silver Spring, Maryland.
- Heimbuch, D.G., H. Wilson, S. Weisburg, J. Volstad, and P. Kazyak. 1997. Estimating fish abundance in stream surveys using double-pass removal sampling. In: Maryland Biological Stream Survey: Ecological status of non-tidal streams in six basins sampled in 1995 (Appendix B). Prepared by Versar, Inc. for Maryland Department of Natural Resources, Monitoring and Non-tidal Assessment Division. Annapolis, Maryland. CBWP-MANTA-EA-97-2.
- ITFM (Intergovernmental Task Force on Monitoring). 1995. The strategy for improving water-quality monitoring in the United States. Final report of the Water Quality. Intergovernmental Task Force on Monitoring Water Quality. Reston, Virginia.
- Jenkins, R. and N. Burkhead. 1994. Freshwater Fishes of Virginia. American Fisheries Society. Bethesda, Maryland.

- Kazyak, P. 1996. Maryland biological stream survey sampling manual. Maryland Department of Natural Resources. Monitoring and Non-tidal Assessment Division. Annapolis, Maryland.
- Kernan, A. 1997. Personal communication. Maryland Department of Natural Resources. Days Cove, Maryland.
- Leasner, L. 1997. Personal communication. Maryland Department of Natural Resources. Annapolis, Maryland.
- MDE (Maryland Department of the Environment). 1996. 1996 303(d) list of waters. Toxics and Regulatory Support Administration. Baltimore, Maryland.
- MGS (Maryland Geological Survey). 1996. Directory of mineral producers in Maryland—1995. Maryland Department of Natural Resources. Information Circular No. 53. Baltimore, Maryland.
- MOP (Maryland Office of Planning). 1991. Final report: Preparation of 1990 land use/land cover maps and ARC/INFO digital database. . Baltimore, Maryland.
- MOP (Maryland Office of Planning). 1994. 1994 Land use report. Baltimore, Maryland.
- Morgan, R. 1995. Personal communication. University of Maryland. Appalachian Laboratory. Frostburg, Maryland.
- Motivans, K. 1997. Personal communication. Maryland Department of Natural Resources. Forest, Wildlife, and Heritage Administration. Middletown, Maryland.
- MSP (Maryland Department of State Planning). 1969. Manual of Coordinates. Publication No. 155. Baltimore, Maryland.
- NOAA (National Oceanic and Atmospheric Administration). 1997. Climatological Data Annual Summary; Maryland and Delaware (1996). Volume 120, No. 13. National Climatic Data Center. Ashville, North Carolina.
- ONR (Ontario Ministry of Natural Resources). 1976. Reptiles and amphibians of Algonquin Provincial Park. Ontario, Canada.
- Orth, R. J., G. Nowak, D. Anderson, J. Wilcox, J. Whiting, and L. Nagey. 1996. Distribution of submerged aquatic vegetation in the Chesapeake Bay and tributaries and Chincoteague Bay-1995. Final Report to EPA. Chesapeake Bay Program, Annapolis, Maryland.
- Page, G. 1997. Personal communication. Alliance for the Chesapeake Bay. Towson, Maryland.
- Plafkin, J., M. Barbour, K. Porter, S. Gross, and R. Hughes. 1989. Rapid bioassessment protocols for use in stream and rivers; benthic macroinvertebrates and fish (EPA/444/4-89-001). U.S. Environmental Protection Agency. Washington, D.C.
- Platts, W.S., W. Megahan and G. Minshall. 1983. Methods for evaluating stream, riparian and biotic conditions. General Technical Report: INT-138. Intermountain Research Station, Forest Service, U.S. Department of Agriculture. Ogden, Utah.
- Rankin, E. 1989. The Qualitative Habitat Evaluation Index (QHEI): rationale, methods and application. Division of Water Quality Planning and Assessment. Ohio Environmental Protection Agency. Columbus, Ohio.
- Robbins, C.S., and E.A.T. Blom. 1996. Atlas of the breeding birds of Maryland and the District of Columbia. University of Pittsburgh Press. Pittsburgh, Pennsylvania.
- Rohde, F., R. Arndt, D. Lindquist, and J. Parnell. 1994. Freshwater fishes of the Carolinas, Virginia, Maryland and Delaware. University of North Carolina Press. Chapel Hill, North Carolina.
- Roth, N. E., M. Southerland, J. Chaillou, R. Klauda, P. Kazyak, S. Stranko, S. Weisberg, L. Hall, and R. Morgan. 1997. Maryland Biological Stream Survey: Development of a fish index of biotic integrity. In: Maryland Biological Stream Survey: Ecological status of non-tidal streams in six basins sampled in 1995 (Appendix C). Prepared by Versar, Inc. for Maryland Department of Natural Resources, Monitoring and Non-tidal Assessment Division. Annapolis, Maryland. CBWP-MANTA-EA-97-2.

Scarpulla, G. 1997. Personal communication. Baltimore City Department of Public Works. Baltimore, Maryland.

Siano, F. 1997. Personal communication. Maryland Department of the Environment. Technical and Regulatory Support Administration. Baltimore, Maryland.

SOS (Maryland Save our Streams). 1994. Project Heartbeat. Volunteer Monitoring Handbook; Fall 1994. Glen Burnie, Maryland.

Strahler, A. 1964. Quantitative geomorphology of drainage basins and channel networks: Section 4-2 in

Handbook of applied hydrology (ed. Ven te Chow). McGraw-Hill. New York, New York.

Strayer D. 1983. The effects of surface geology and stream size on freshwater mussel (*Bivalvia*, *Unionidae*) distribution in southwestern Michigan, USA. *Freshwater Biology*.(13) 253-264.

USGS (U.S. Geological Survey). 1953. Drainage areas in Maryland, Delaware, and Pennsylvania. Water Resources Administration. Washington, D.C.

Volstad, J., M. Southerland, S. Weisberg, H. Wilson, D. Heimbuch, and J. Seibel. 1995. Maryland biological stream survey: 1994 demonstration project. Draft report. Versar, Inc. Columbia, Maryland.

Watters, G. 1993. Mussel diversity as a function of drainage area and fish diversity: management implications. In: Conservation and Management of Freshwater Mussels: Proceedings of a UMRCC Symposium, St. Louis, Missouri.

WDNR (Wisconsin Department of Natural Resources). 1977. Use of arthropods to evaluate water quality of streams. Technical Bulletin Number 100. Madison, Wisconsin.

Maryland Citizen and Watershed Organizations. Sources: 1) **Guidance Manual for Volunteer Water Quality Monitoring in Maryland 1995.** Maryland Volunteer Water Quality Monitoring Association. Available through the U.S. Fish and Wildlife Service (see below), and 2) **Alliance for the Chesapeake Bay (ACB) 1996. Watershed Directory, 1996 Edition. A Guide to Citizen, River and Watershed Organizations Working in the Chesapeake Bay Watershed.** Available through the ACB (see below).

Organization	Address	River Basin
Alliance for the Chesapeake Bay	6600 York Rd. Baltimore, MD 21212	Chesapeake Bay
Audubon Naturalist Society	8940 Jones Mill Rd. Chevy Chase, MD 20815	Several
Baltimore County Forest Conservancy District Board	9405 Old Harford Road Baltimore, MD 21234	
Free State Fly Fishers	PO Box 614 Annapolis, MD 21401	Various
Gunpowder Valley Conservancy	PO Box 261 Kingsville, MD 21087	Big/Little Gunpowder Falls
Maryland Save Our Streams	258 Scotts Manor Dr. Glen Burnie, MD 21061	Various
Trout Unlimited	2916 Trellis Lane. Abingdon, MD 21009	Various
Watershed Protection Coalition, Inc.	PO Box 212 Timonium, MD 21094-0212	Baltimore City-owned watersheds

SYNOPSIS OF MBSS DESIGN AND SAMPLING METHODS

The MBSS is intended to provide unbiased estimates of the condition of streams and rivers of Maryland on a local (e.g., drainage basin or county) as well as a statewide scale. To date, the MBSS has focused on wadeable, headwater streams. The survey is based on a probabilistic stream sampling approach where random selections are made from all sections of streams in the state which can physically be sampled. The approach supports statistically-valid population estimation of variables of interest (e.g., largemouth bass densities, miles of streams with degraded physical habitat, etc.). When repeated, the MBSS will also provide a basis for assessing future changes in ecological condition of flowing waters of the state. At present, plans are to repeat the MBSS at five year intervals and develop a quantitative sampling approach for larger streams and rivers.

The study area for the MBSS includes each of the major 18 major drainage basins of the state, and a total of three years is required to sample all 18 basins. For logistical reasons, the state was divided into three geographic regions (east, west, and central) with five to seven basins in each region. Each basin is sampled at least once during a given three year cycle, and one basin in each region is sampled twice so that data collected in different years can be combined into a single statewide estimate for each of the variables of interest.

The sampling frame for the MBSS was constructed by overlaying basin boundaries on a map of all blueline stream reaches in the state as digitized on a U.S. Geological Survey 1:250,000 scale map. Sampling within basins is restricted to non-tidal, first, second and third-order (Strahler 1964) stream reaches, excluding unwadeable or otherwise unsampleable areas. An additional restriction is that only public lands or privately-owned sites where landowner permissions have been obtained are sampled.

During 1996, the MBSS sample sites were selected from a comprehensive list of headwater stream reaches in 7 of the 18 drainage basins. To provide adequate information about each size of stream, an approximately equal number of first, second and third order streams were sampled during spring and summer, with the number of sites of each order in a basin being proportional to the number of stream miles (of an order) in the entire state.

Benthic macroinvertebrates and water quality samples were collected during the spring index period from March through early May, while fish, herpetofauna, *in situ* stream chemistry and physical habitat sampling were conducted during the low flow period in the summer, from June through September.

In the spring, water samples were collected and analyzed for pH, acid-neutralizing capacity (ANC), sulfate, nitrate, conductivity, and dissolved organic carbon (DOC) in the laboratory. These variables primarily characterize the sensitivity of the streams to acid deposition, and to other anthropogenic stressors to a lesser extent. Benthic macroinvertebrates collected in the spring were identified to family and genus level in the laboratory.

Habitat assessments were conducted in the summer using metrics largely patterned after EPA's Rapid Bioassessment Protocols and Ohio EPA's Qualitative Habitat Evaluation Index (QHEI) described by Rankin (1989), Plafkin *et al.* (1989), and Platts *et al.* (1983) in the designated 75 m length of the stream segments; riparian habitat measurements were based on the surrounding area within 20 m of the segment. Other qualitative measurements included (1) aesthetic value, based on evidence of human refuse; (2) remoteness, based on the absence of detectable human activity and difficulty in accessing the segment; (3) land use, based on the surrounding area immediately visible from the segment; (4) general stream character, based on the shape, substrate, and vegetation of the segment; and (5) bank erosion, based on the kind and extent of erosion present. Quantitative measurements at each segment included flow, depth, wetted width, and stream gradients.

Fish and herpetofauna were sampled during the summer index period using quantitative, double-pass electrofishing of the 75 m stream segments. Blocking nets were placed at each end of the segment, and one or more direct-current, backpack electrofishing units were used to sample the entire segment. All fish captured during each electrofishing pass were identified, counted, weighed in aggregate, and up to 100 individuals of each species were examined for external anomalies such as lesions and tumors. All gamefish captured were also measured for length. Any amphibians, reptiles, freshwater molluscs, submerged aquatic vegetation either in or near the stream segment were collected and identified.

For all phases of the MBSS, there was a ongoing, documented program of quality assurance/quality control (QA/QC). The QA/QC program used by the MBSS allows for generation of data with known confidence.

**STREAMS SAMPLED IN THE GUNPOWDER BASIN IN 1996 AS PART
OF THE MARYLAND BIOLOGICAL STREAM SURVEY (MBSS)
(QUANTITATIVE SAMPLES ONLY)**

As described in Chapter 3 and Appendix B, MBSS sampling sites were selected randomly from 1:250,000 scale maps. Many very small streams were selected—some with names and some without. Stream names were acquired for the MBSS database from several map sources. Those streams with no names are called unnamed tributaries. Many streams in Maryland share the same name. For example, in addition to the Piney Run sampled by MBSS in the Gunpowder River basin, there are 3 other Piney Runs in Maryland. Statewide, there are also 5 Piney Branches and 6 Piney Creeks (MSP 1969).

Baismans Run
Beaverdam Run
Beetree Run
Bush Cabin Run (2 sites)
Carroll Branch (2 sites)
Carroll Branch Unnamed Tributary
Councilmans Run
Cowen Run
Delaware Run (2 sites)
Graves Run Unnamed Tributary
Greene Branch
Gunpowder Falls Unnamed Tributary (2 sites)
Gunpowder Falls (4 sites)
Gunpowder Run Unnamed Tributary
Little Gunpowder Falls
Little Falls (4 sites)
Little Gunpowder Run Unnamed Tributary
Little Falls Run Unnamed Tributary
Little Gunpowder Run (2 sites)
Long Greene Creek Unnamed Tributary
Long Green Creek
Murphy Run
Oregon Branch
Parker Branch Unnamed Tributary
Parker Branch (2 sites)
Piney Run (2 sites)
Prettyboy Branch (2 sites)
Second Mine Branch
Third Mine Branch
Unnamed Tributary to Little Falls
Waterspout Run

PHYSICAL HABITAT CONDITIONS MEASURED BY MBSS

I. SUBSTRATE AND INSTREAM COVER

Instream Habitat is rated according to the perceived value of habitat to the fish community. Higher scores are assigned to sites with a variety of habitat types and particle sizes. In addition, higher scores are assigned to sites with a high degree of hypsographic complexity (uneven bottom). In streams where substrate types are favorable but flows are so low that fish are essentially precluded from using the habitat, low scores are assigned. If none of the habitat within a segment is useable by fish, a score of zero is assigned.

Epifaunal Substrate is rated based on the amount and variety of hard, stable substrates usable by benthic macroinvertebrates. Because they inhibit colonization, flocculent materials or fine sediments surrounding otherwise good substrates are assigned low scores. Scores are also reduced when substrates are less stable.

Velocity/Depth Diversity is rated based on the variety of velocity/depth regimes present at a site (slow-shallow, slow-deep, fast-shallow, and fast-deep). As with embeddedness, this metric may result in lower scores in low-gradient streams but will provide statewide information on the physical habitat found in Maryland streams.

Pool/Glide/Eddy Quality is rated based on the variety and spatial complexity of slow or still water habitat within the sample segment. In high-gradient streams, functionally important slow water habitat may exist in the form of larger eddies. Within a category, higher scores are assigned to segments which have undercut banks, woody debris or other types of cover for fish.

Riffle/run Quality is based on the depth, complexity, and functional importance of riffle/run habitat in the segment, with highest scores assigned to segments dominated by deeper riffle/run areas, stable substrates, and a variety of current velocities.

Embeddedness is a percentage of surface area of larger particles that is surrounded by fine sediments on the stream bottom. In low gradient streams embeddedness may be high even in unimpaired streams.

II. CHANNEL CHARACTER

Channel Alteration is a measure of large-scale changes in the shape of the stream channel. Channel alteration includes: concrete channels, artificial embankments, obvious straightening of the natural channel, rip-rap, or other structures, as well as recent bar development. Ratings for this metric are based on the presence of artificial structures as well as the existence, extent, and coarseness of point bars, side bars, and mid-channel bars which indicate the degree of flow fluctuations and substrate stability. Evidence of channelization may sometimes be seen in the form of berms which parallel the stream channel.

Bank Stability is rated based on the presence/absence of riparian vegetation and other stabilizing bank materials such as boulders and rootwads, and frequency/size of erosional areas. Sites with steep slopes are not penalized if banks are composed solely of stable materials.

Channel Flow Status is the percentage of the stream channel that has water, with subtractions made for exposed substrates and dewatered areas.

III. RIPARIAN CORRIDOR

Shading is rated based on estimates of the degree and duration of shading at a site during summer, including any effects of shading caused by landforms.

Riparian Buffer is rated according to the size and type of the vegetated riparian buffer zone at the site. Cultivated fields for agriculture which have bare soil to any extent are not considered as riparian buffers. At sites where the buffer width is variable or direct delivery of storm runoff or sediment to the stream is evident or highly likely, the narrowest representative buffer width in the segment (e.g., 0 if parking lot runoff enters directly to the stream) is measured and recorded even though some of the stream segment may have a well developed riparian buffer.

IV. AESTHETICS/REMOTENESS

Aesthetics are rated according to the visual appeal of the site and presence/absence of human refuse, with highest scores assigned to stream segments with no human refuse and visually outstanding character.

Remoteness is rated based on the absence of detectable human activity and difficulty in accessing the segment.

ECOLOGY AND DISTRIBUTION OF FISH SPECIES COLLECTED IN NON-TIDAL STREAMS OF THE GUNPOWDER RIVER BASIN

The species descriptions (Jenkins and Burkhead 1994, Rohde *et al.* 1994) and distributional maps which follow (Figures E1-E39) include those fish species collected during both random and non-random sampling efforts as part of the 1996 MBSS in the Gunpowder River basin.

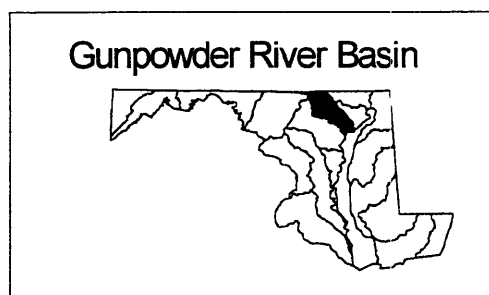
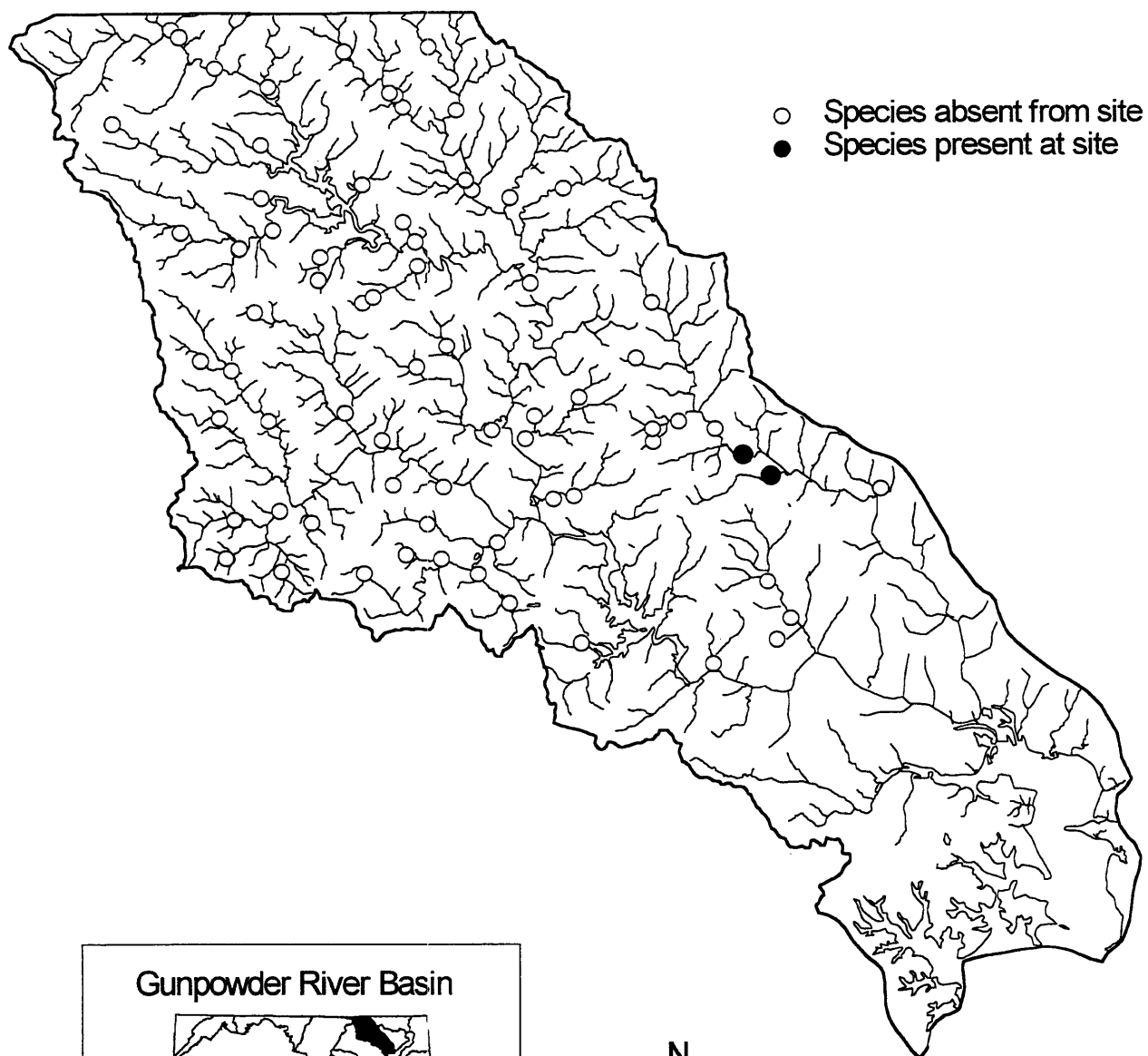
Common Name	Family	Tolerance	Feeding Groups	Distribution Map	Interesting Facts
Sea lamprey	Lamprey	Moderate	Filter Feeder (during stream residency)	E-1	This species was found at only 2 sites in the basin. Adults live in the ocean and use freshwater streams to spawn (anadromous).
American eel	Eel	Tolerant	Generalist	E-2	Although most of their life is spent in freshwater streams (up to 20 years or more), adults become silver in color before their long journey to the Sargasso sea to spawn (catadromous).
Blacknose dace	Minnow	Tolerant	Omnivore	E-3	This species was found at nearly all sites in the basin, possibly because it is tolerant of a wide range of environmental conditions and pollutants.
Bluntnose minnow	Minnow	Tolerant	Omnivore	E-4	As the name implies, this species is characterized by an extremely blunt snout.
Central stoneroller	Minnow	Moderate	Algivore	E-5	Because of its long intestine (up to 8 times its body length), this species is incredibly efficient at digesting detritus and algae.
Common shiner	Minnow	Moderate	Omnivore	E-6	This species often becomes more abundant when cold water streams become stressed by high temperatures.

Common Name	Family	Tolerance	Feeding Groups	Distribution Map	Interesting Facts
Creek chub	Minnow	Tolerant	Generalist	E-7	This species was found at nearly all sites in the basin. Although this minnow doesn't have teeth around the jaw, it is quite capable of taking large prey items and readily strike at lures intended for trout.
Cutlips minnow	Minnow	Moderate	Invertivore	E-8	This species is named for the presence of a bony lower jaw bordered on each side by a soft oval lobe.
Fallfish	Minnow	Moderate	Generalist	E-9	Found at only 1 site, this is one of the least abundant species in the basin. The male fallfish may build a large nest of gravel (some of which are over 3 feet high) to protect its mate's eggs.
Fathead minnow	Minnow	Tolerant	Omnivore	E-10	As a result of bait-bucket introductions, this minnow is widely distributed throughout the eastern United States, however it was only found at 1 site in the basin.
Longnose dace	Minnow	Moderate	Omnivore	E-11	Its streamlined body shape and large fins allow this minnow to move around easily and remain stationary in fast currents.
River chub	Minnow	Moderate	Omnivore	E-12	During the breeding season, the male develops tubercles on its head and vigorously defends its nest from other males and egg-foraging predators.
Rosyside dace	Minnow	Intolerant	Invertivore	E-13	This species was present at all of the second and third order sites. This minnow is considered to be sensitive to heavy siltation.
Satinfin shiner	Minnow	Moderate	Invertivore	E-14	This species is considered a good aquarium fish because of its active nature and ready acceptance of dried food.
Silverjaw minnow	Minnow	Moderate	Omnivore	E-15	This species is readily identified by a network of honeycomb-like canals below its eyes.
Spottail shiner	Minnow	Moderate	Omnivore	E-16	This species is found in a wide range of habitats, including tidal freshwater areas where it can be highly abundant.

Common Name	Family	Tolerance	Feeding Groups	Distribution Map	Interesting Facts
Swallowtail shiner	Minnow	Moderate	Invertivore	E-17	This species seems to use both minnow and sunfish nests for spawning, unlike other minnows which only spawn on other minnow nests.
Northern hogsucker	Sucker	Intolerant	Invertivore	E-18	Considered to be an aggressive feeder, this species has been known to overturn stones and gravel in search of food. Because of its highly camouflaged coloration, large schools of this species often go unnoticed by the casual observer.
White sucker	Sucker	Tolerant	Omnivore	E-19	Large white suckers have been reported to reach 17 years of age and lengths of over 23 inches.
Brown bullhead	Catfish	Tolerant	Omnivore	E-20	Although considered native to Maryland, this species has been widely introduced throughout the United States to provide fishing opportunities.
Margined madtom	Catfish	Moderate	Invertivore	E-21	This is a highly nocturnal species which requires hiding places to thrive. The spines of the margined madtom are venomous and can inflict considerable pain if handled incorrectly.
Yellow bullhead	Catfish	Tolerant	Omnivore	E-22	Although bullheads are considered bottom feeders, when given the opportunity they are quite capable of catching and eating fish such as minnows and sunfish.
Brook trout	Trout	Intolerant	Generalist	E-23	This species was found mostly in first order sites in the basin. Commonly found in cold headwater streams, this species is the only trout native to Maryland.
Brown trout	Trout	Moderate	Top Predator	E-24	This European species was widely introduced prior to 1900 and has contributed to the widespread decline of brook trout in the eastern United States. Because of its wariness, this trout presents a great challenge to both spin and fly fishermen.
Rainbow trout	Trout	Moderate	Top Predator	E-25	This species was found at only 1 site. Although ranked among the top 5 sought after gamefish in North America, hatchery -reared fish are not considered as desirable by many fishing purists.

Common Name	Family	Tolerance	Feeding Groups	Distribution Map	Interesting Facts
Mummichog	Killifish	Moderate	Invertivore	E-26	Although freshwater populations exist, this species is more commonly found in estuaries and is known to tolerate salinities up to 32 parts per thousand.
Mosquitofish	Topminnow	Moderate	Invertivore	E-27	As the name implies, this species has been known to control mosquito populations by feeding on pupal and larval stages.
Mottled sculpin	Sculpin	Moderate	Insectivore	E-28	This species primarily eats insects and does the majority of its feeding nocturnally.
Bluegill	Sunfish	Tolerant	Invertivore	E-29	This species has been widely introduced throughout the United States, and has flourished as a result of its tolerance to a variety of conditions.
Green sunfish	Sunfish	Tolerant	Generalist	E-30	This species is intolerant of low pH streams, but tolerant of many other types of stress. The lowest pH stream site where this sunfish was collected was 7.43.
Largemouth bass	Sunfish	Moderate	Top Predator	E-31	This species is considered the most popular gamefish in the United States and has been known to reach weights of over 20 pounds.
Longear sunfish	Sunfish	Moderate	Invertivore	E-32	This species was found at only 1 site. This sunfish gets its name from its large earflap which is black with a pale margin.
Pumpkinseed	Sunfish	Moderate	Invertivore	E-33	This sunfish is tolerant of darkly-stained acidic waters and is a regular visitor to brackish waters.
Redbreast sunfish	Sunfish	Moderate	Generalist	E-34	Often found with smallmouth bass and other "cool water" species, this sunfish has been found in water warmer than 100° F.
Rock bass	Sunfish	Moderate	Generalist	E-35	This big-mouthed sunfish is an ambush predator that feeds on a wide variety of minnows and aquatic insects.
Smallmouth bass	Sunfish	Moderate	Top Predator	E-36	One reason for this species' popularity as a gamefish is its aggressive nature and frequent "aerial acrobatics" when hooked on light tackle.

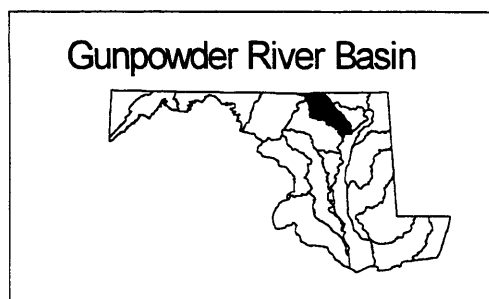
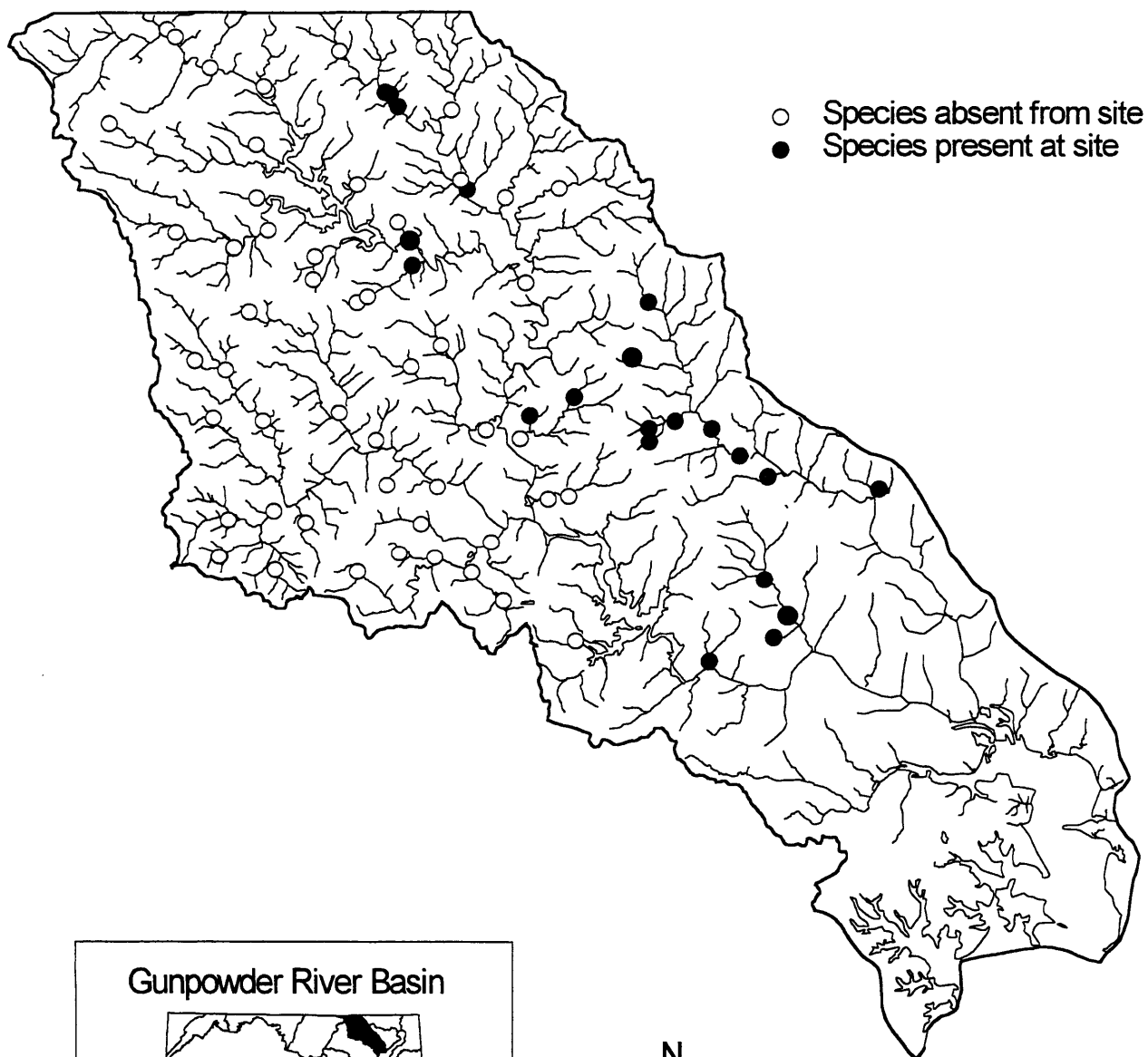
Common Name	Family	Tolerance	Feeding Groups	Distribution Map	Interesting Facts
Fantail darter	Perch	Moderate	Insectivore	E-37	Aided by its small, cone shaped mouth, this insect eater commonly forages in crevices and under rocks.
Shield darter	Perch	Intolerant	Insectivore	E-38	This bottom-dwelling species occupies warm streams and rivers and avoids moderately to heavily silted areas.
Tessellated darter	Perch	Moderate	Invertivore	E-39	The male tessellated darter has a curious behavior of frequently caring for nests containing eggs that it did not fertilize.



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-1. Distribution of sea lamprey in the Gunpowder River basin in 1996.



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-2. Distribution of American eel in the Gunpowder River basin in 1996.

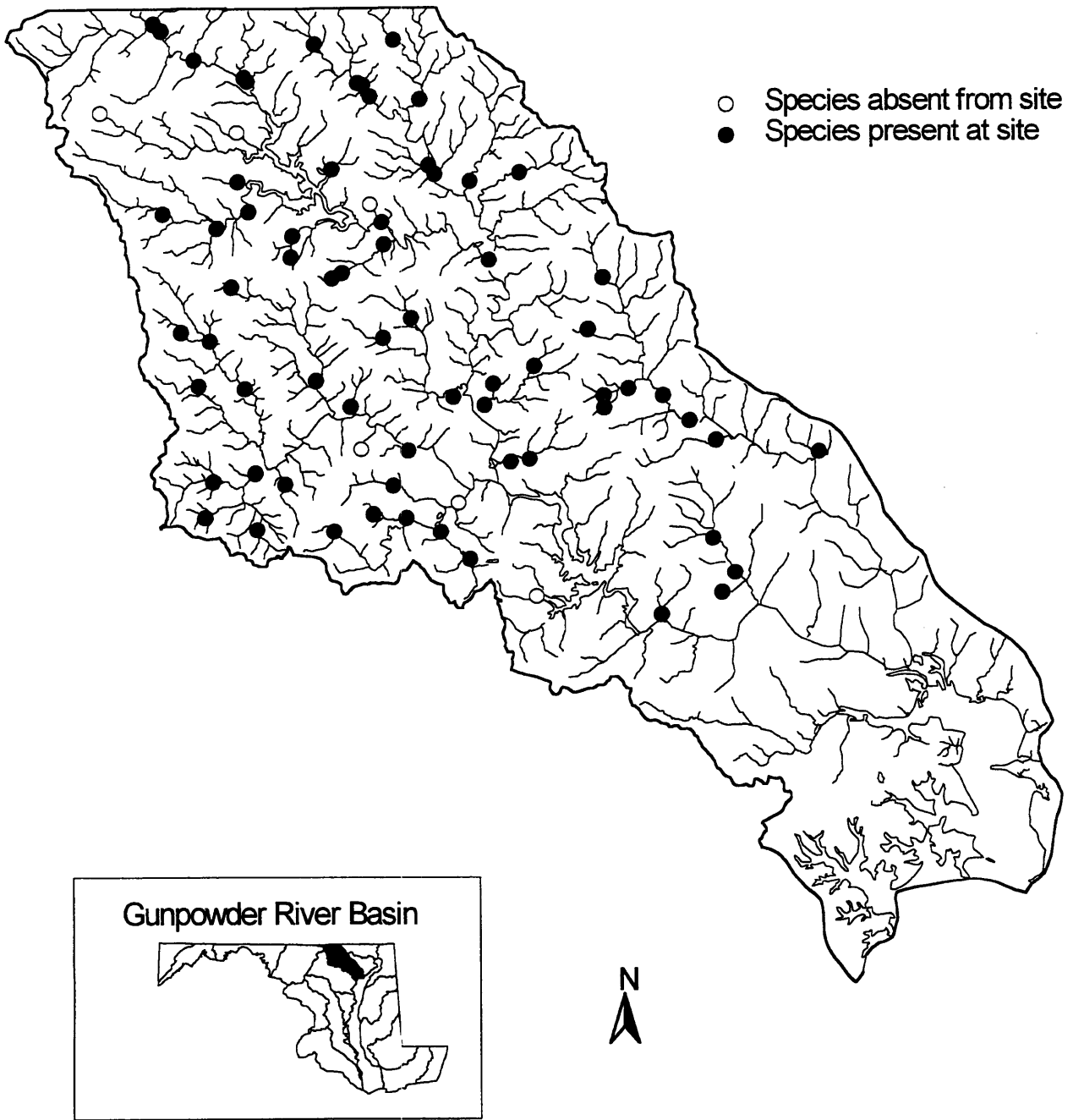


Figure E-3. Distribution of blacknose dace in the Gunpowder River basin in 1996.

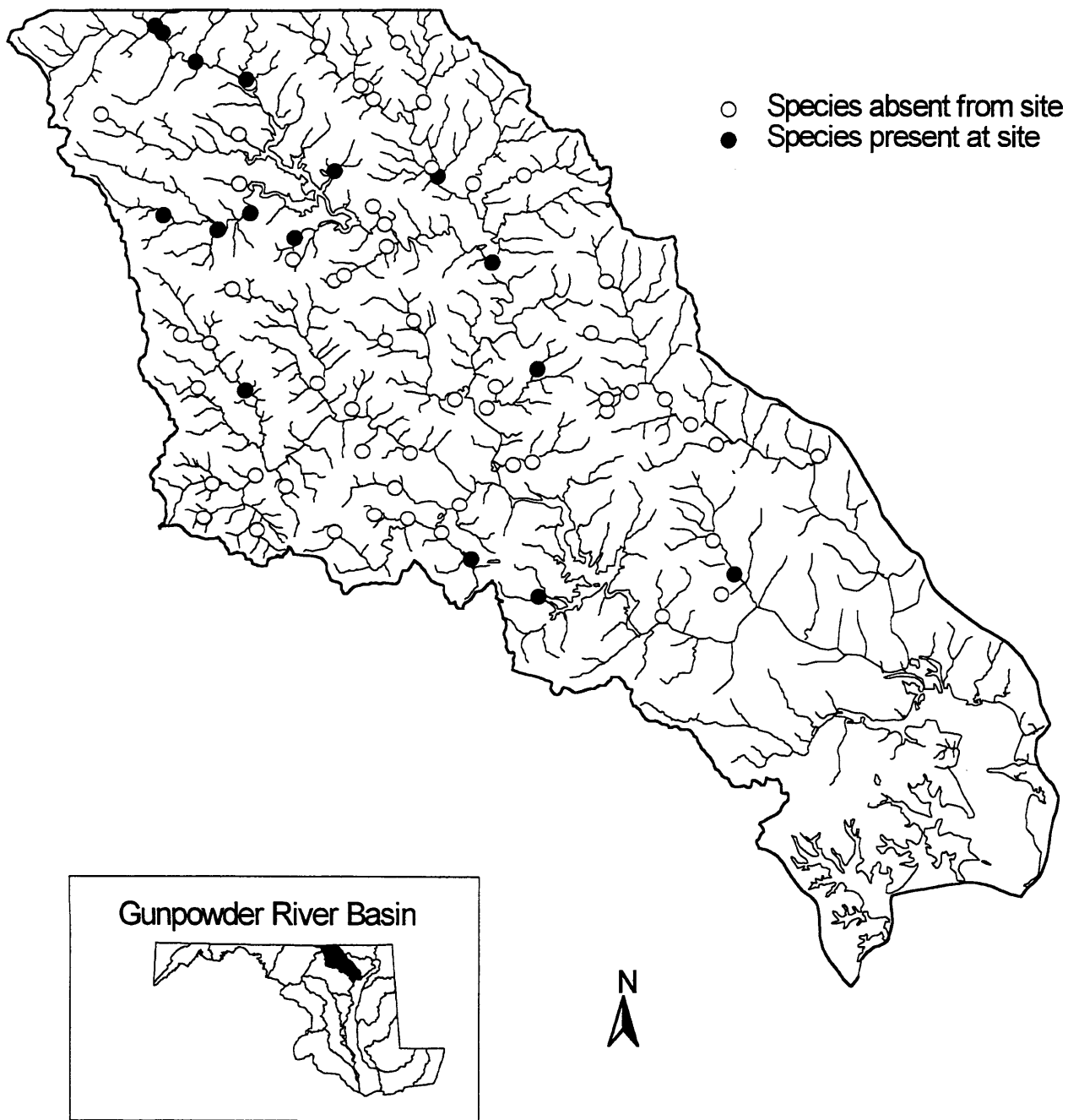


Figure E-4. Distribution of bluntnose minnow in the Gunpowder River basin in 1996.

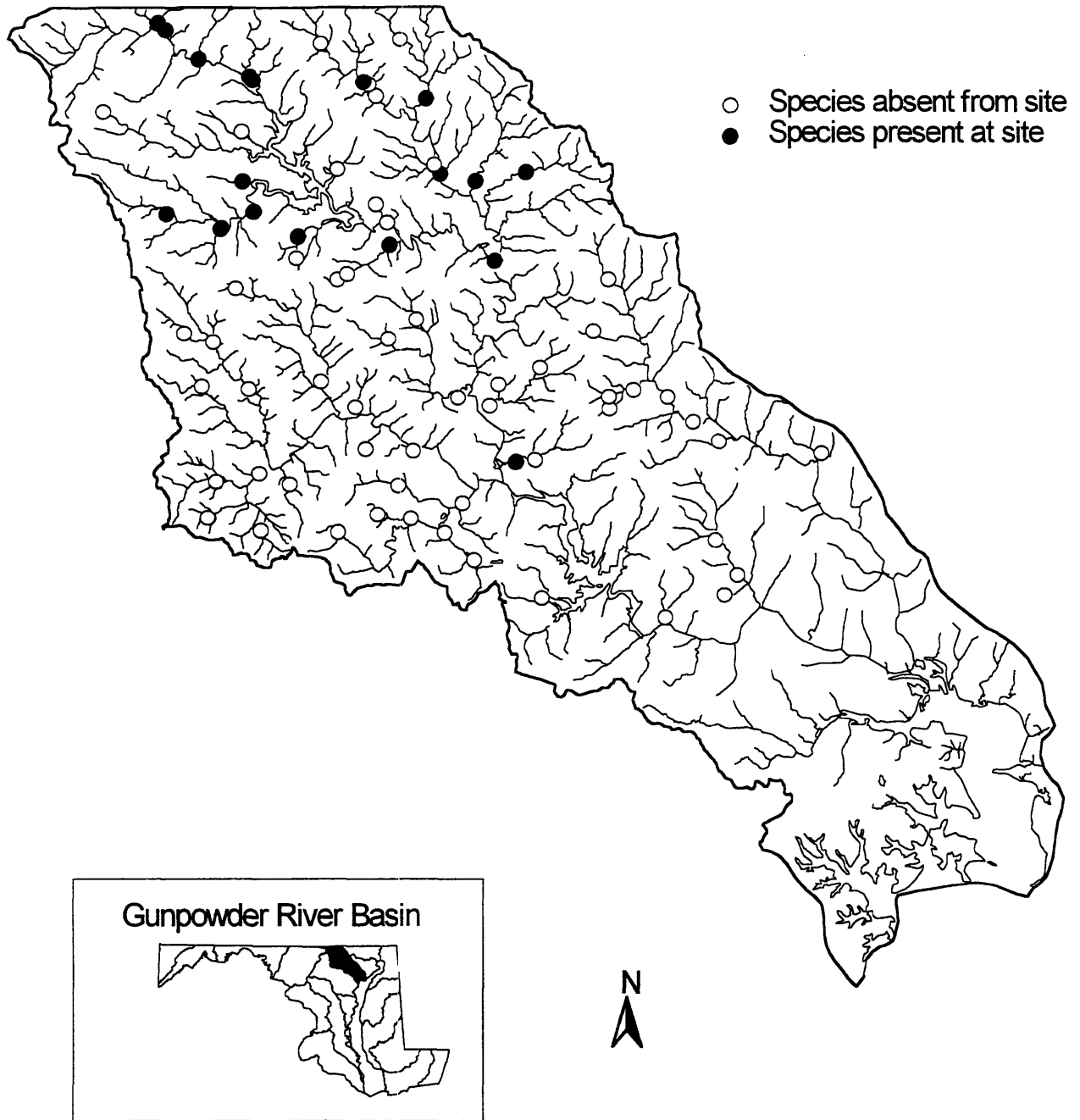
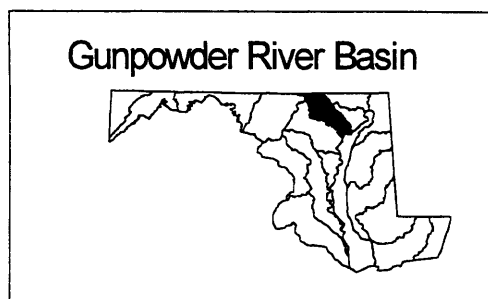
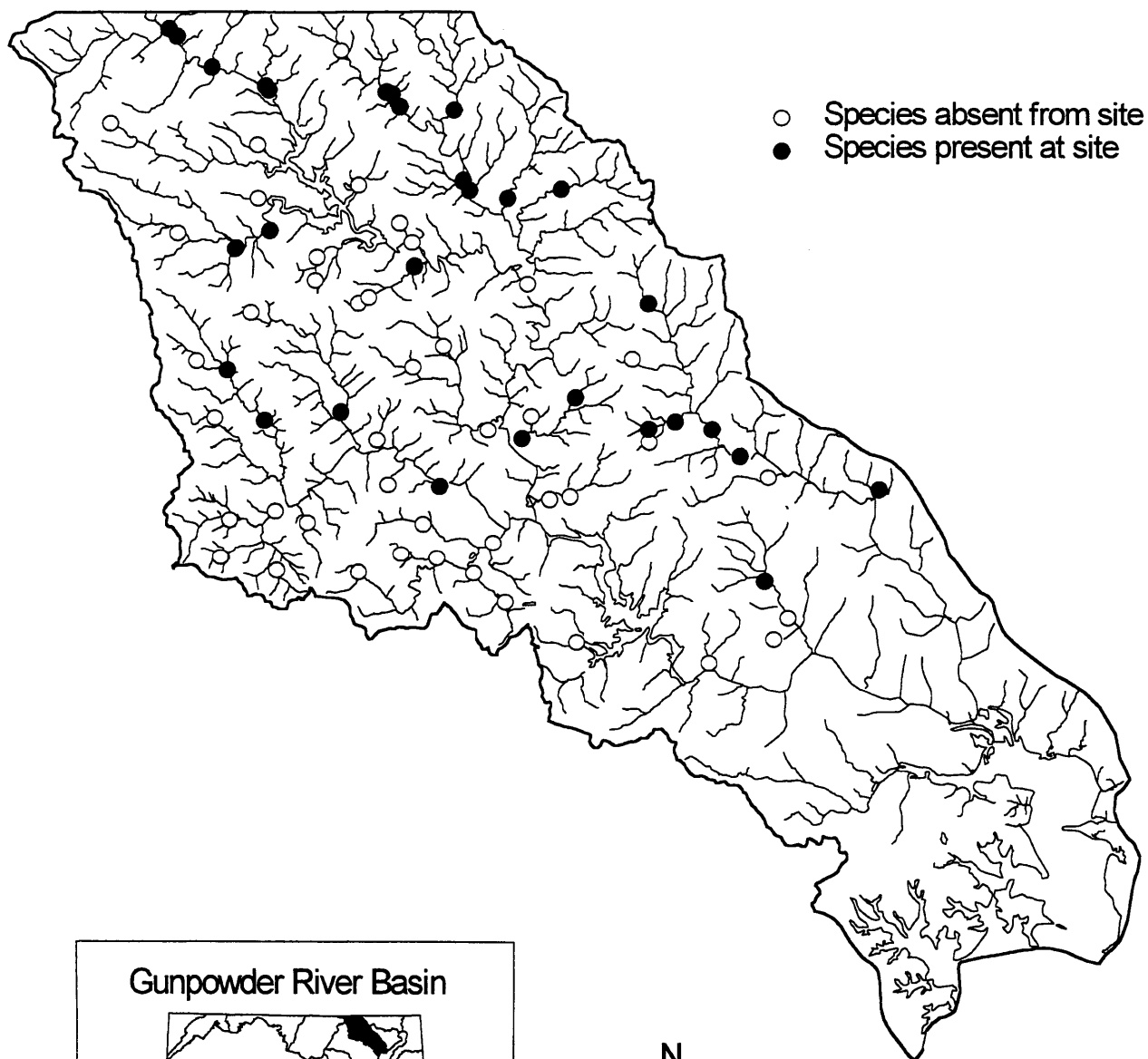


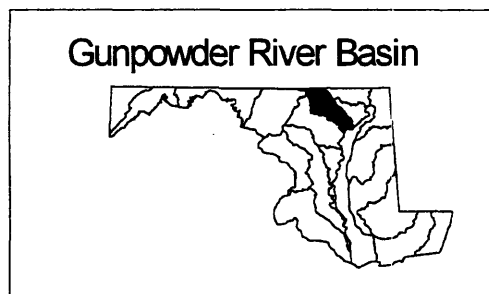
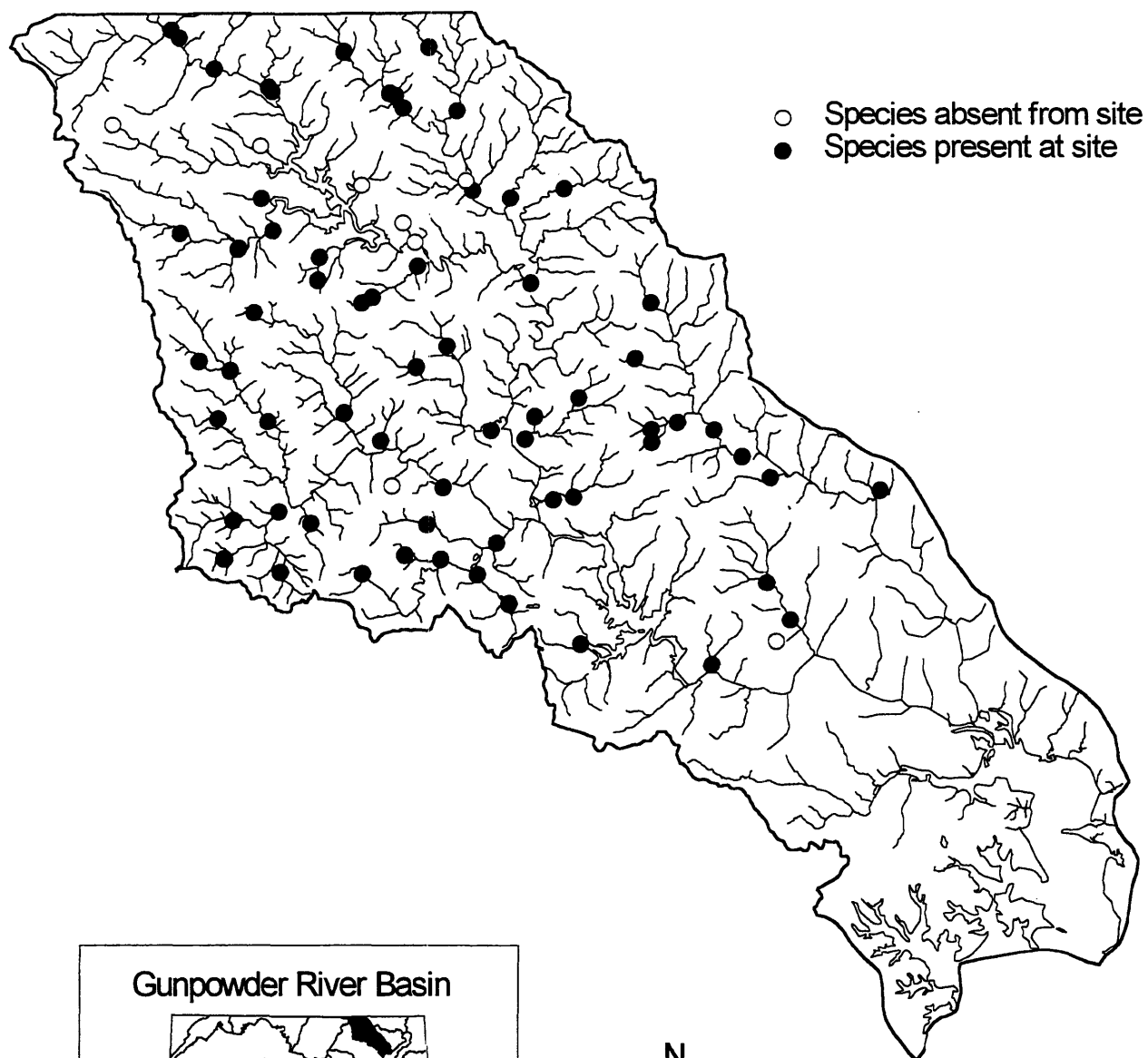
Figure E-5. Distribution of central stoneroller in the Gunpowder River basin in 1996.



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-6. Distribution of common shiner in the Gunpowder River basin in 1996.



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-7. Distribution of creek chub in the Gunpowder River basin in 1996.

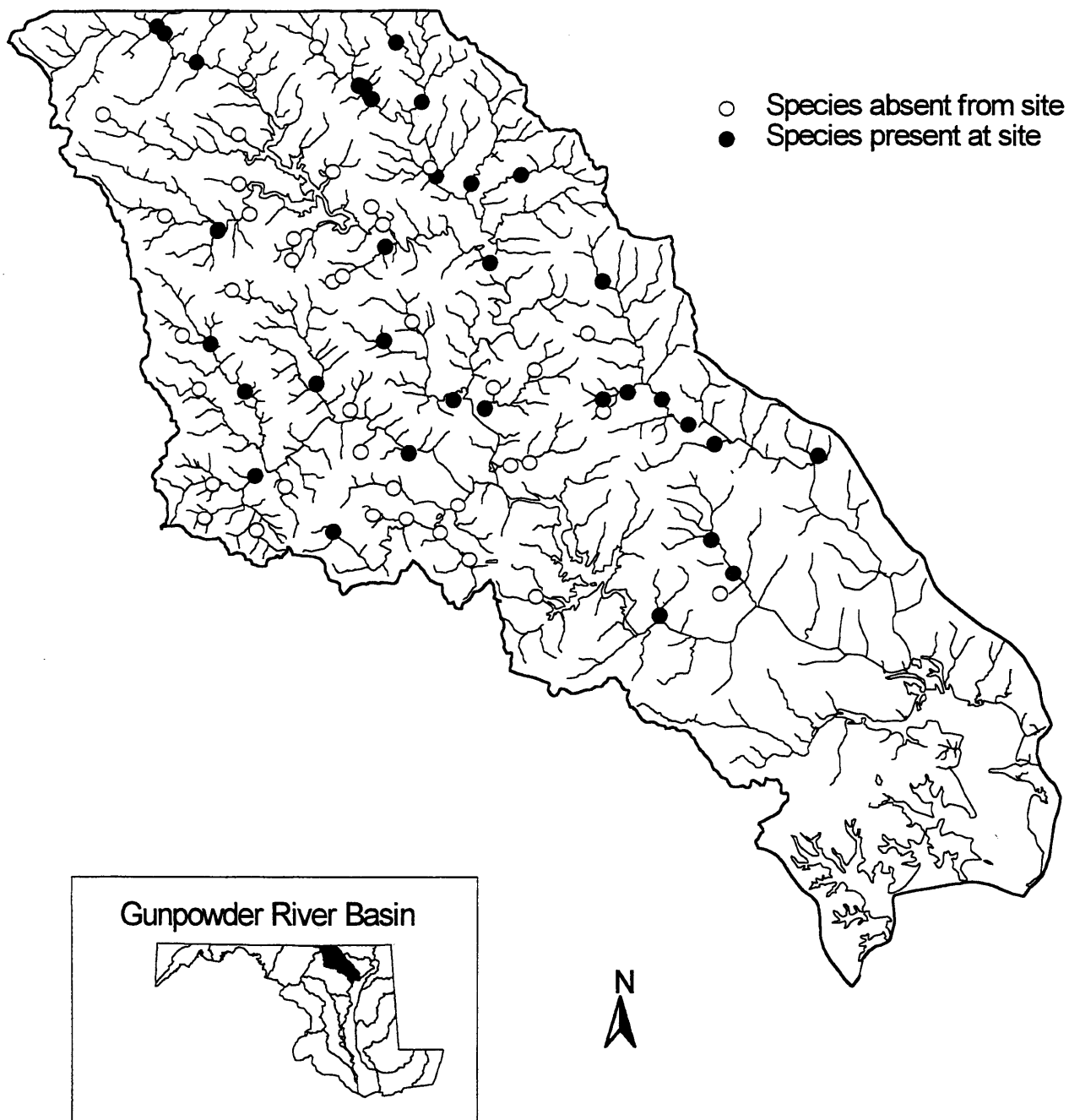
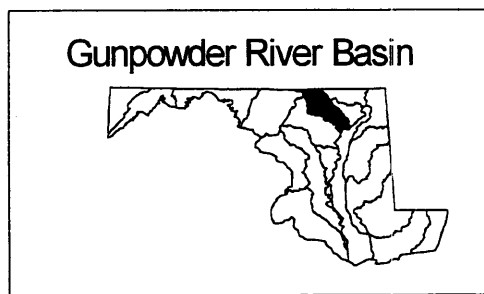
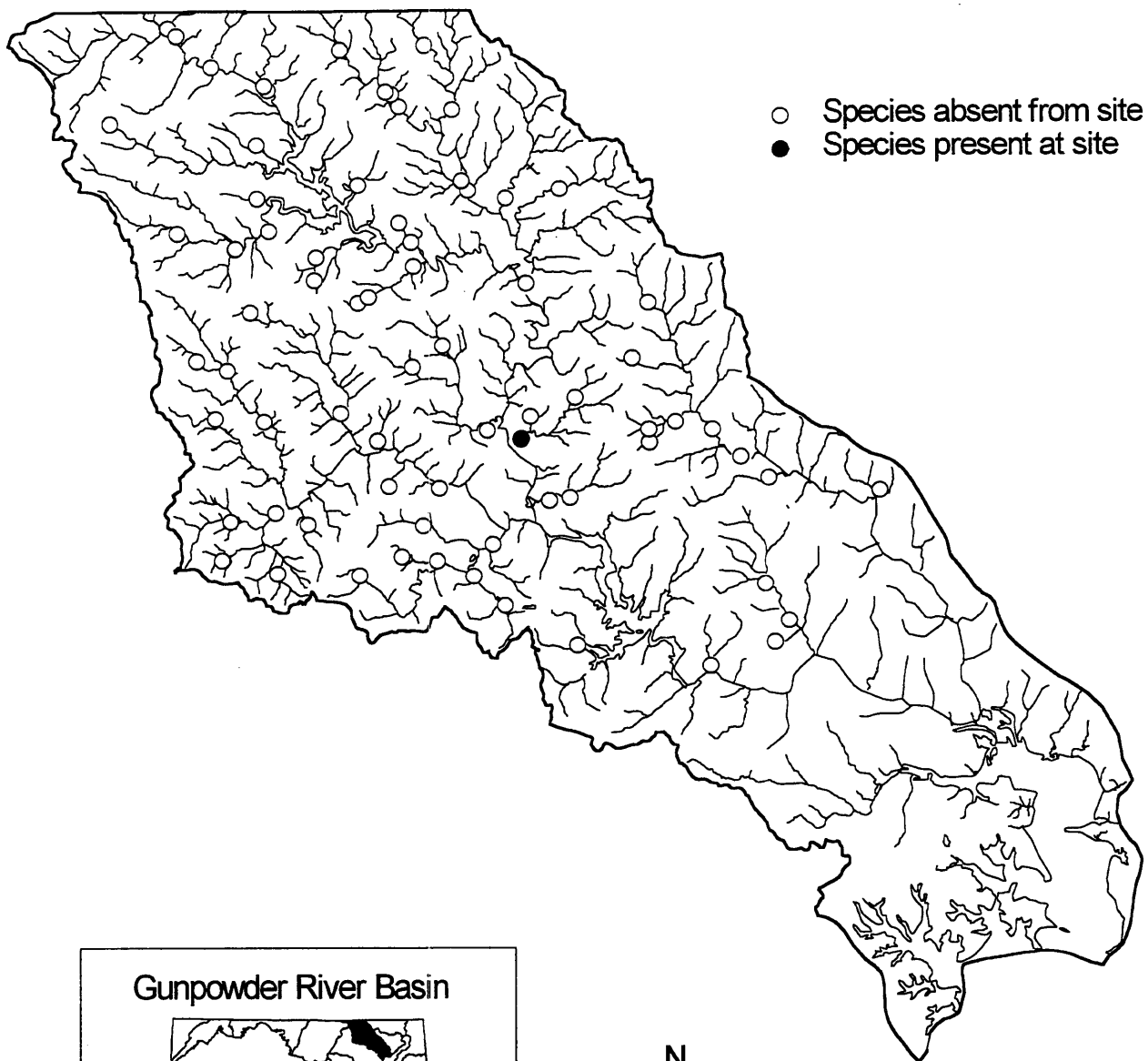


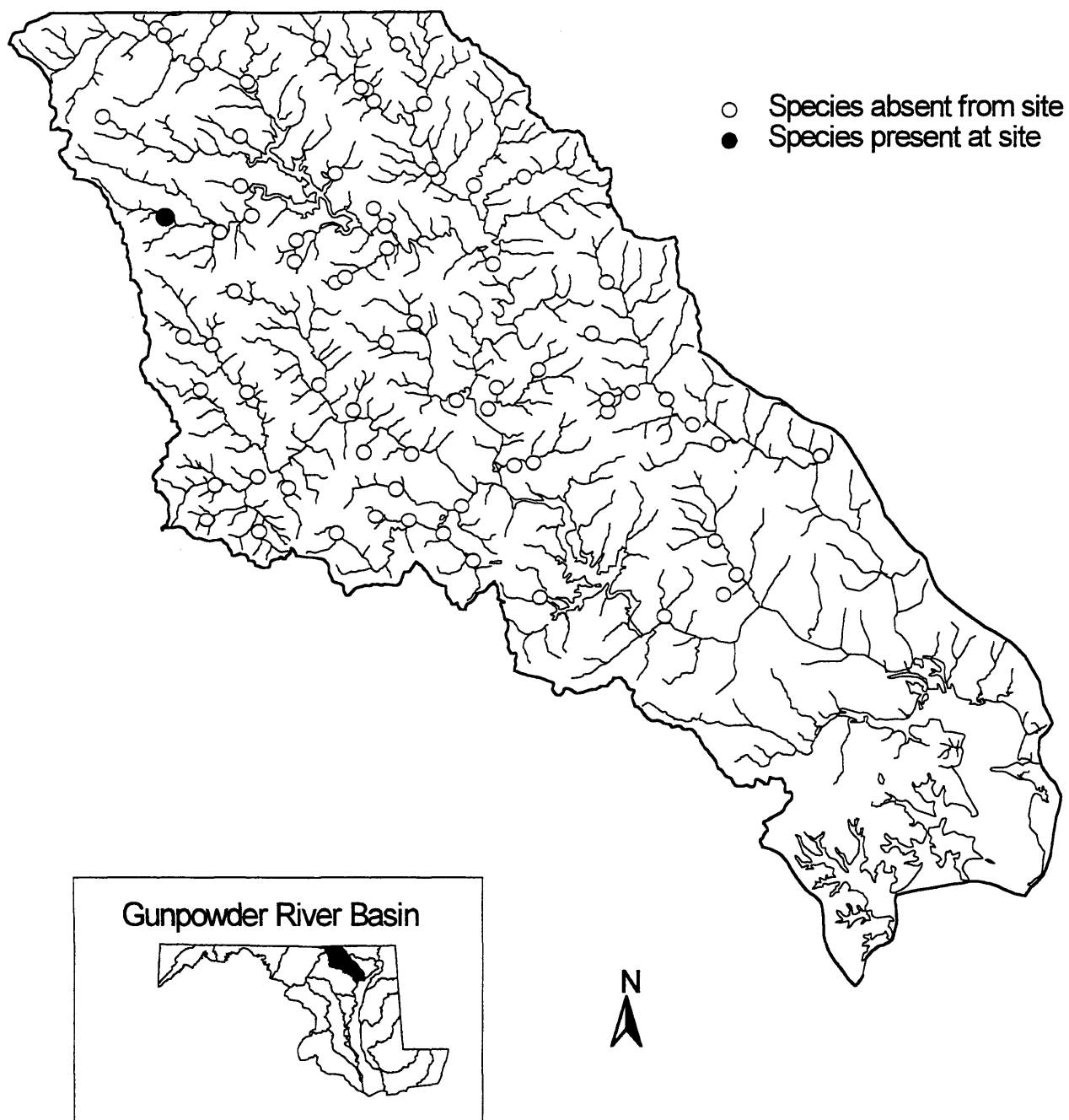
Figure E-8. Distribution of cutlips minnow in the Gunpowder River basin in 1996.



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-9. Distribution of fallfish in the Gunpowder River basin in 1996.



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-10. Distribution of fathead minnow in the Gunpowder River basin in 1996.

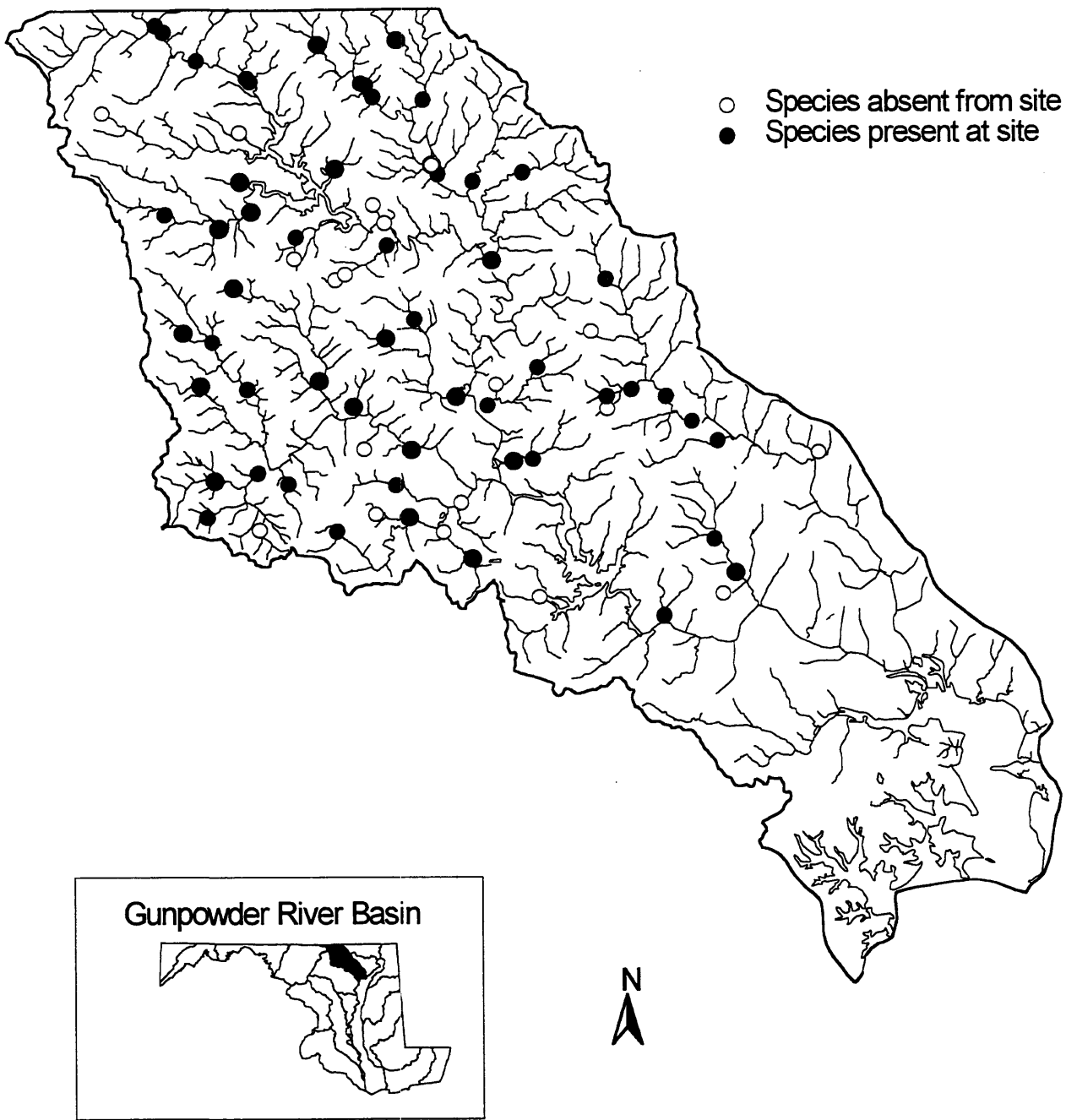
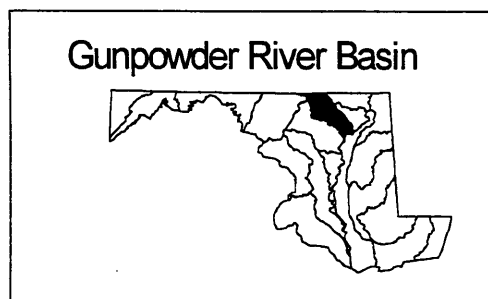
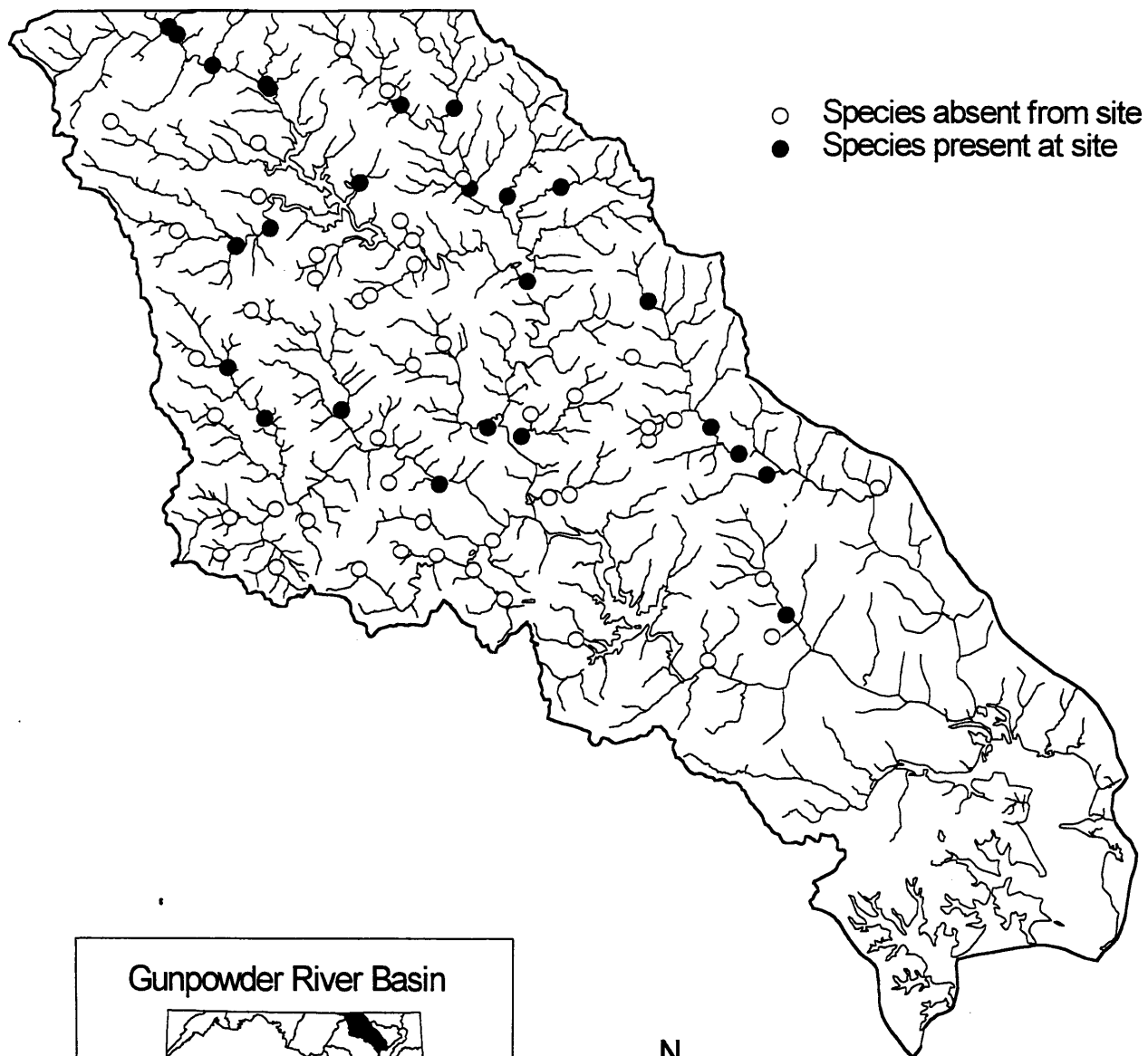


Figure E-11. Distribution of longnose dace in the Gunpowder River basin in 1996.



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-12. Distribution of river chub in the Gunpowder River basin in 1996.

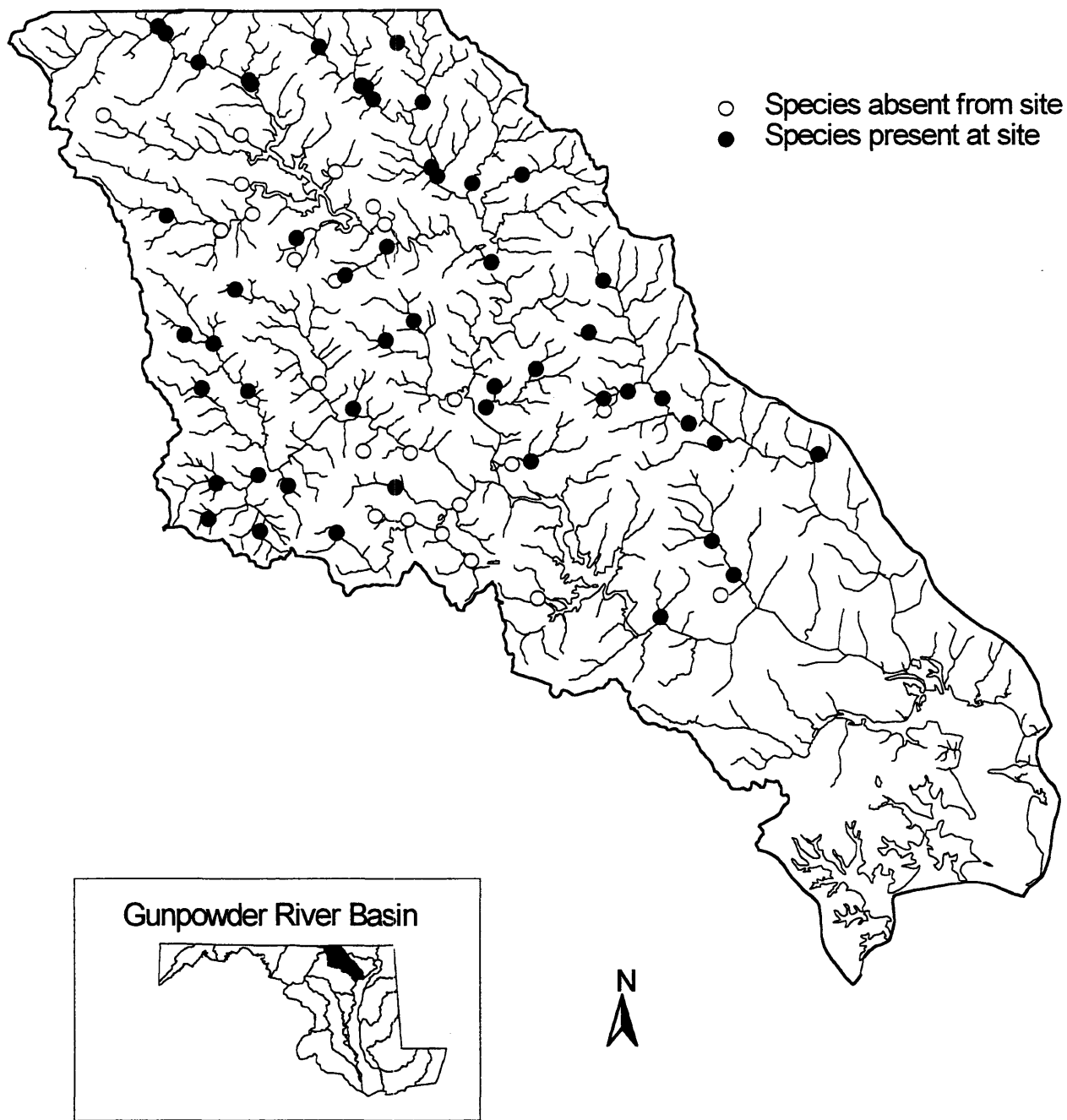
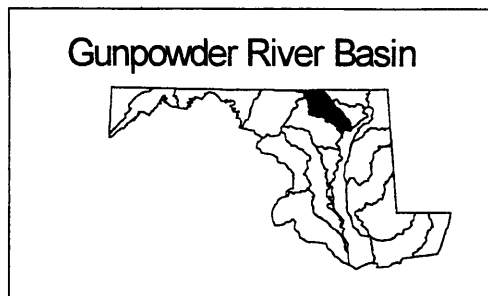
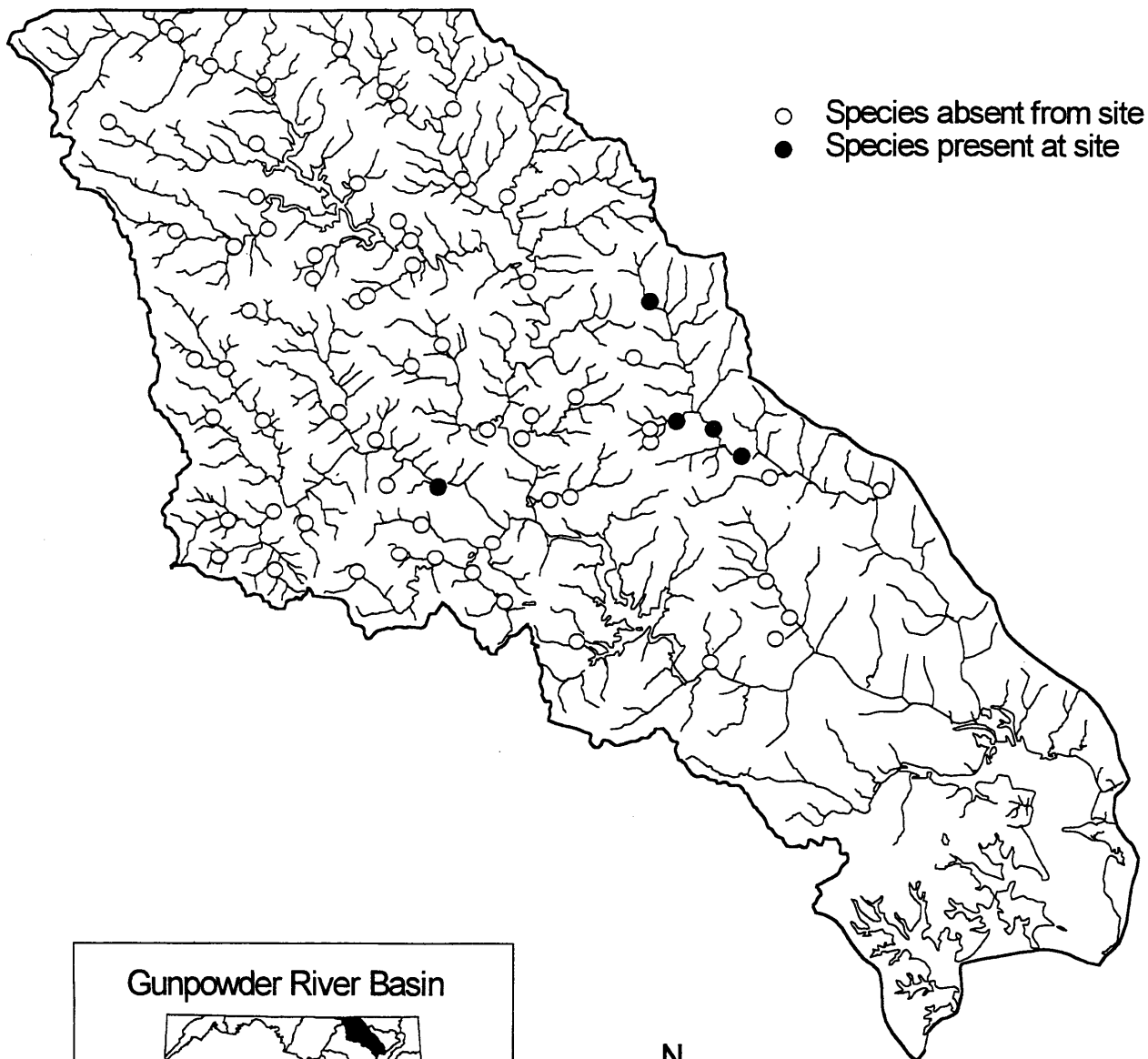


Figure E-13. Distribution of rosyside dace in the Gunpowder River basin in 1996.



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-14. Distribution of satfin shiner in the Gunpowder River basin in 1996.

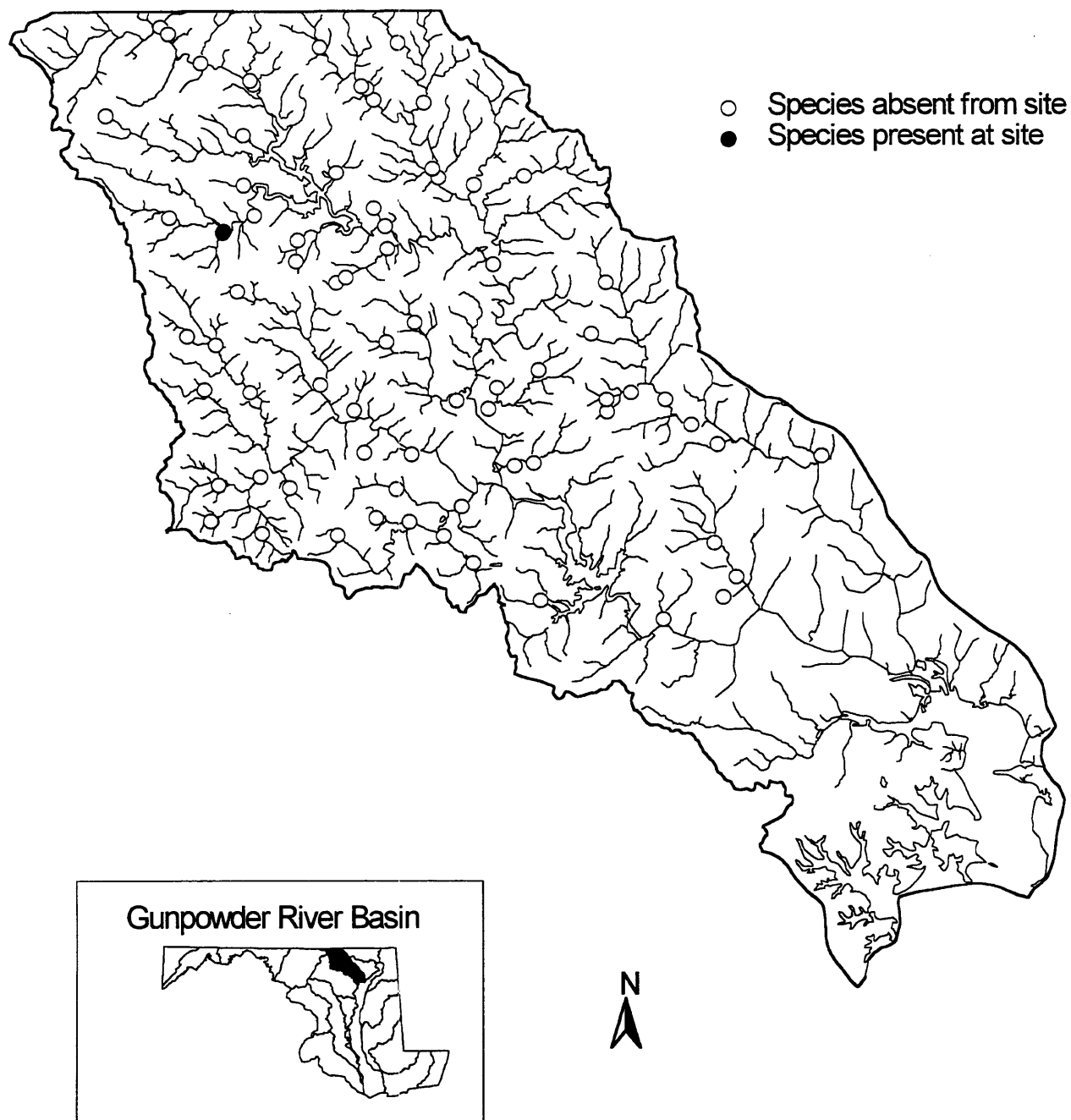


Figure E-15. Distribution of silverjaw minnow in the Gunpowder River basin in 1996.

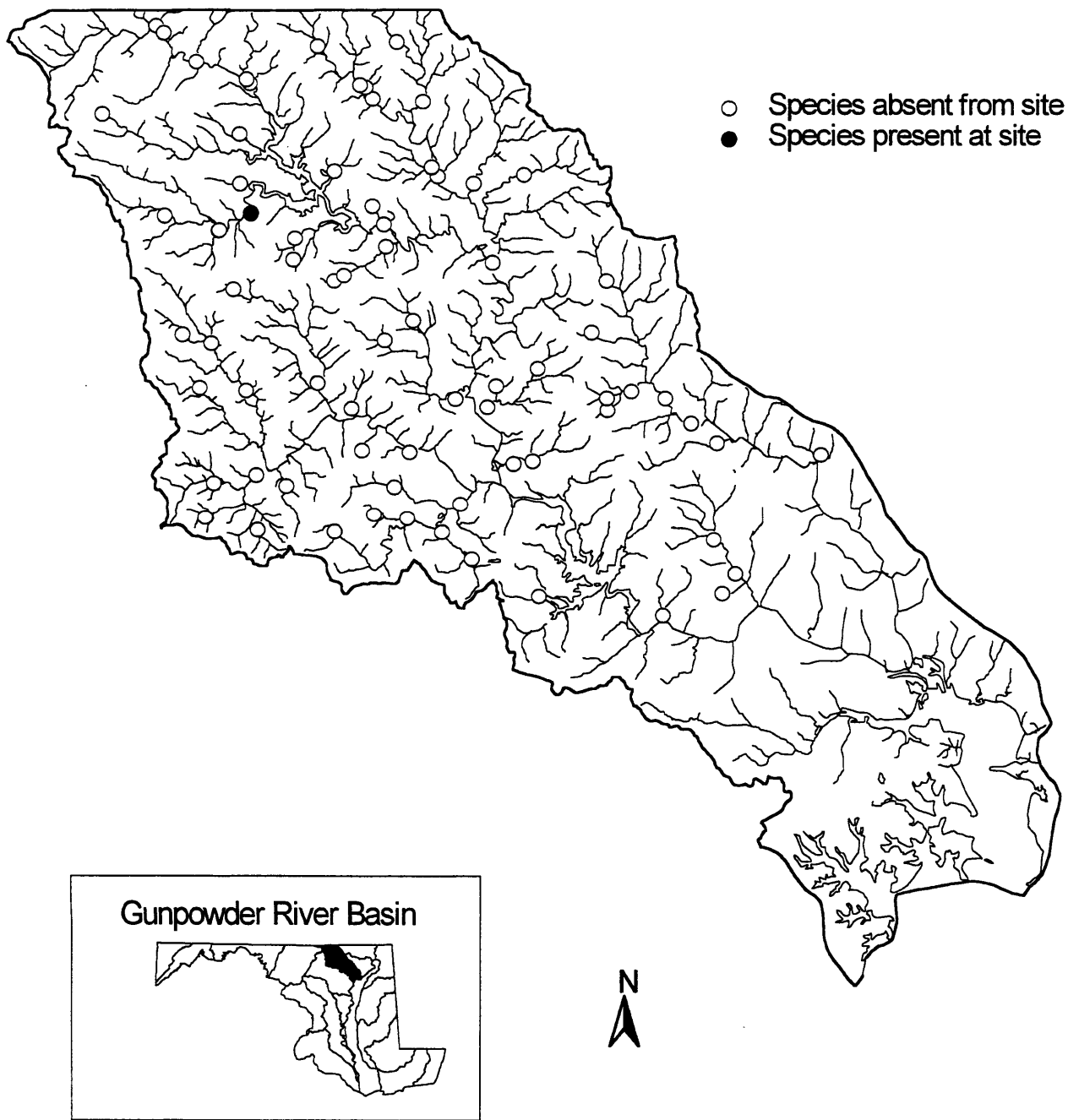


Figure E-16. Distribution of spottail shiner in the Gunpowder River basin in 1996.

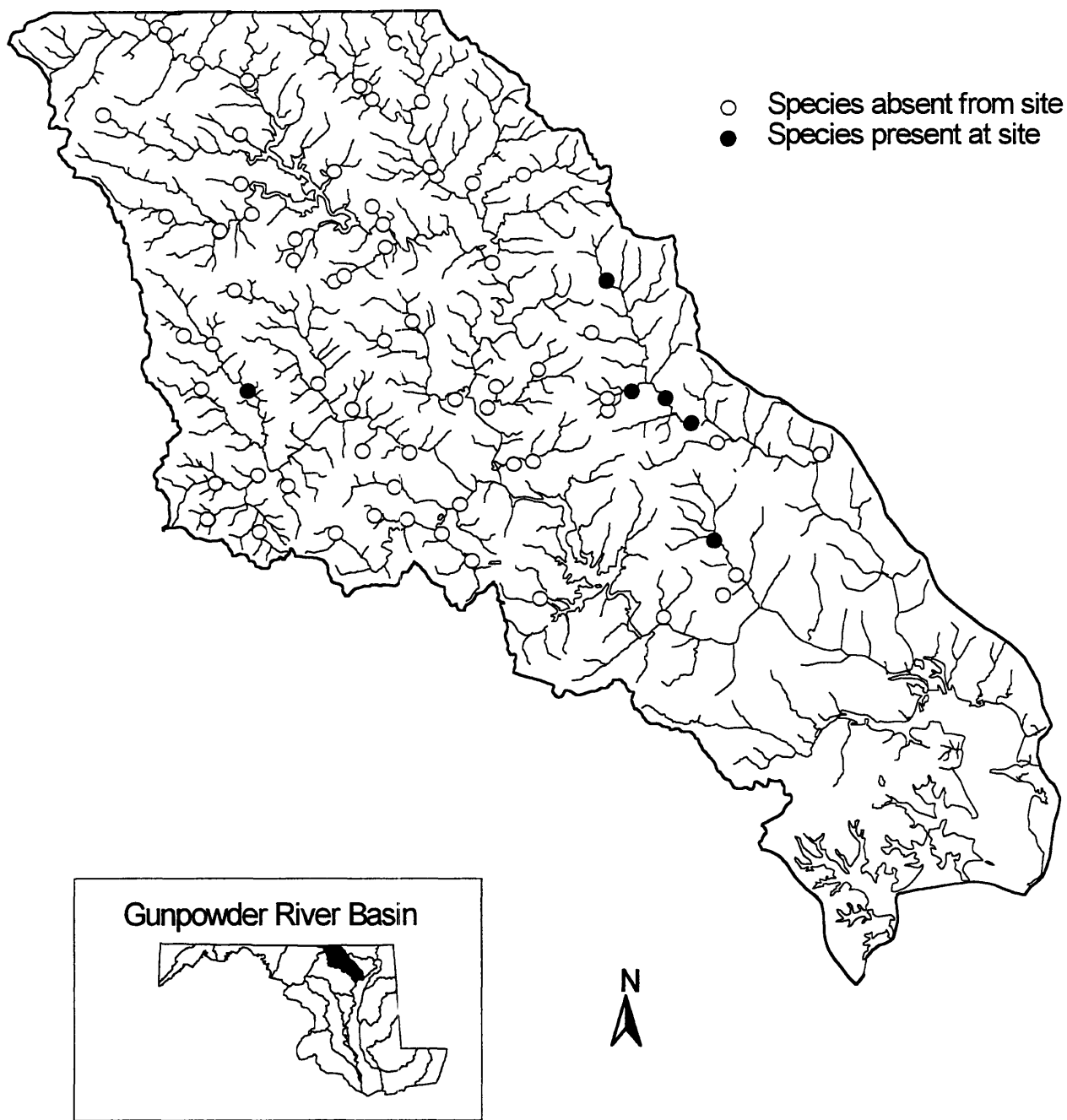
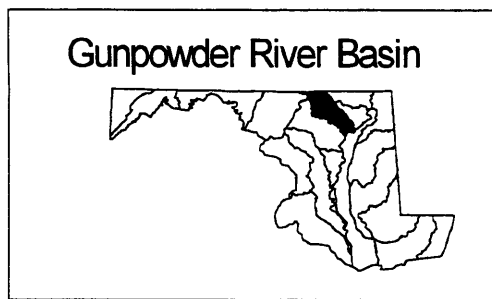
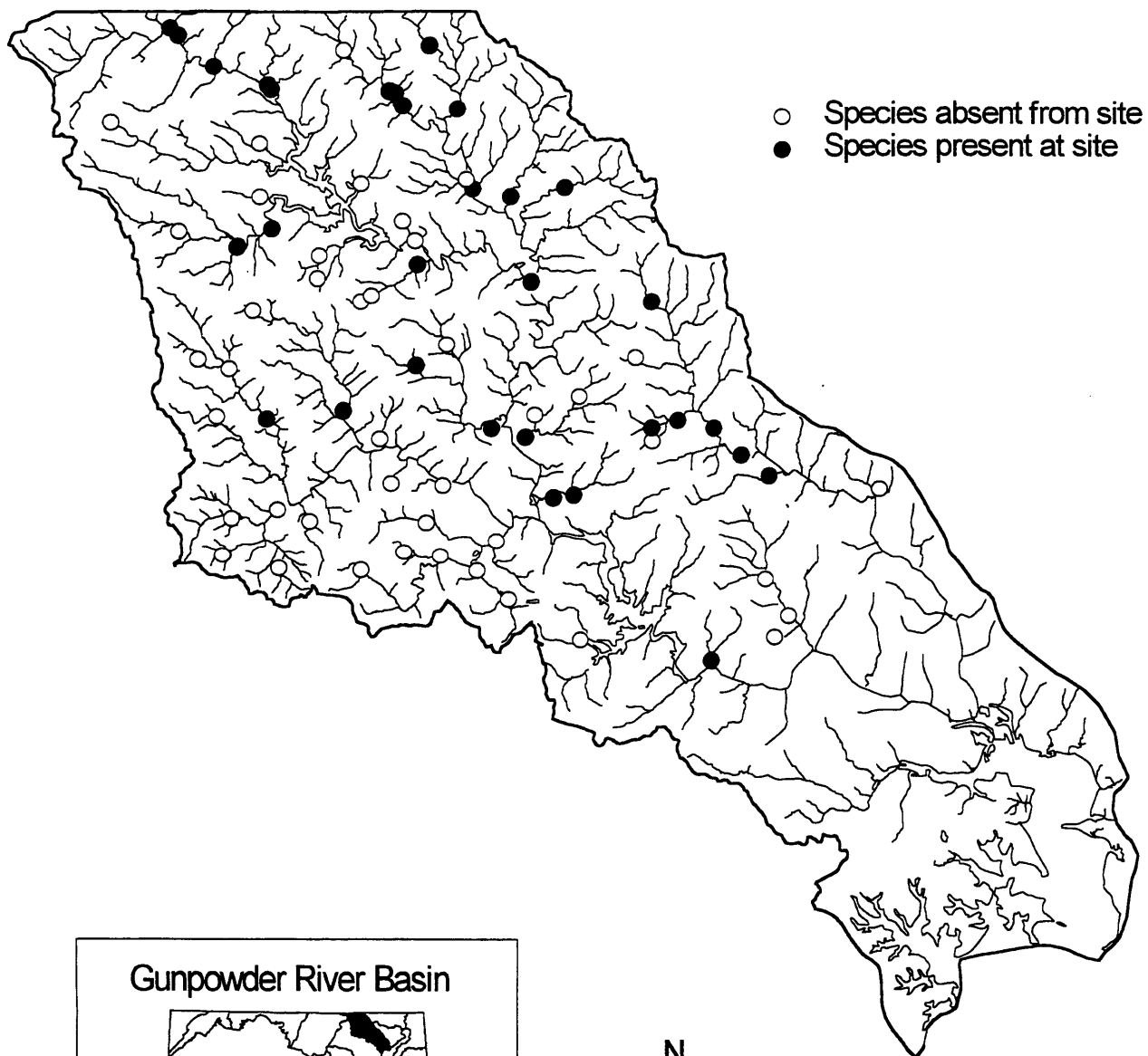


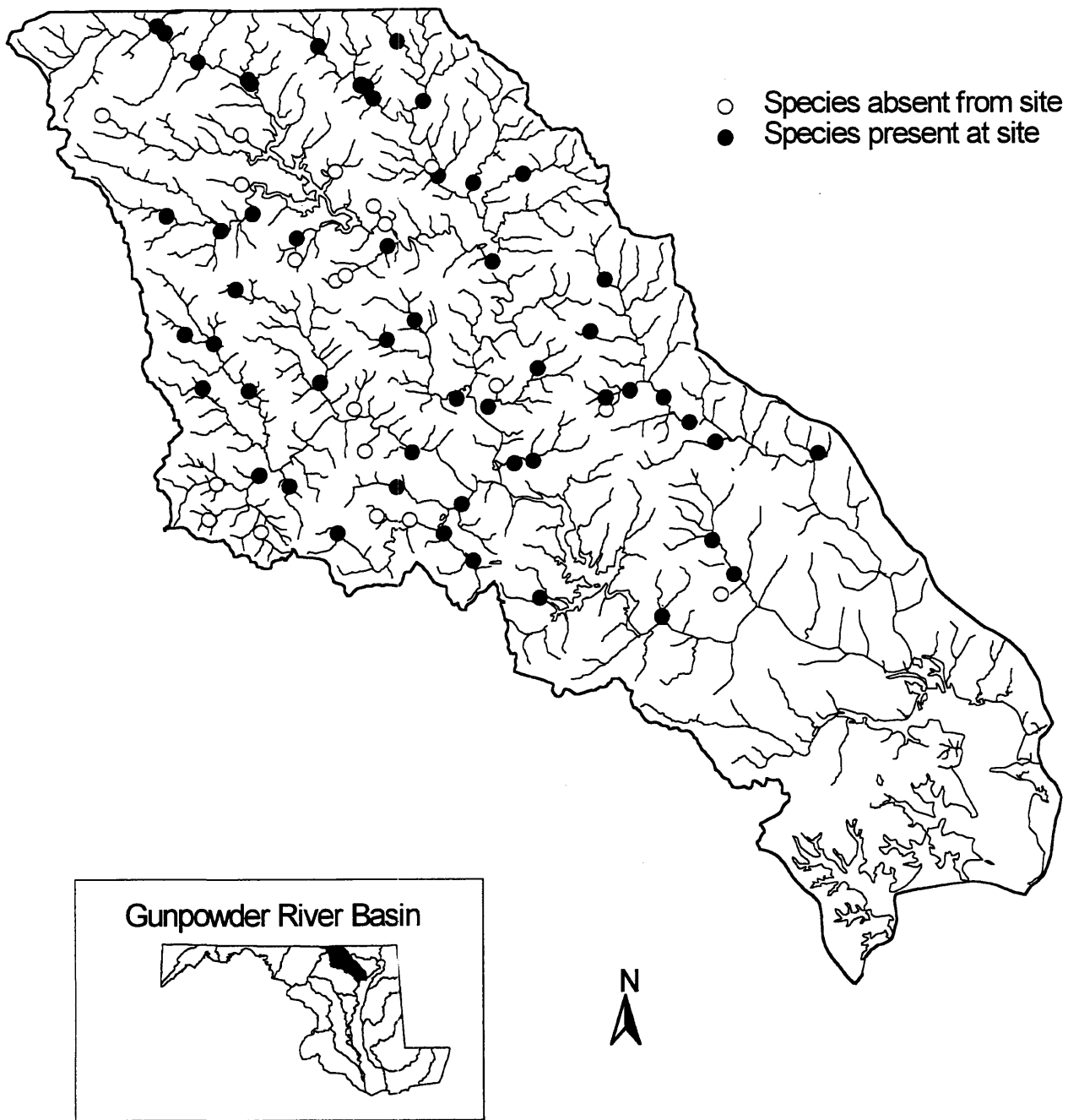
Figure E-17. Distribution of swallowtail shiner in the Gunpowder River basin in 1996.



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-18. Distribution of northern hogsucker in the Gunpowder River basin in 1996.



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-19. Distribution of whiter sucker in the Gunpowder River basin in 1996.

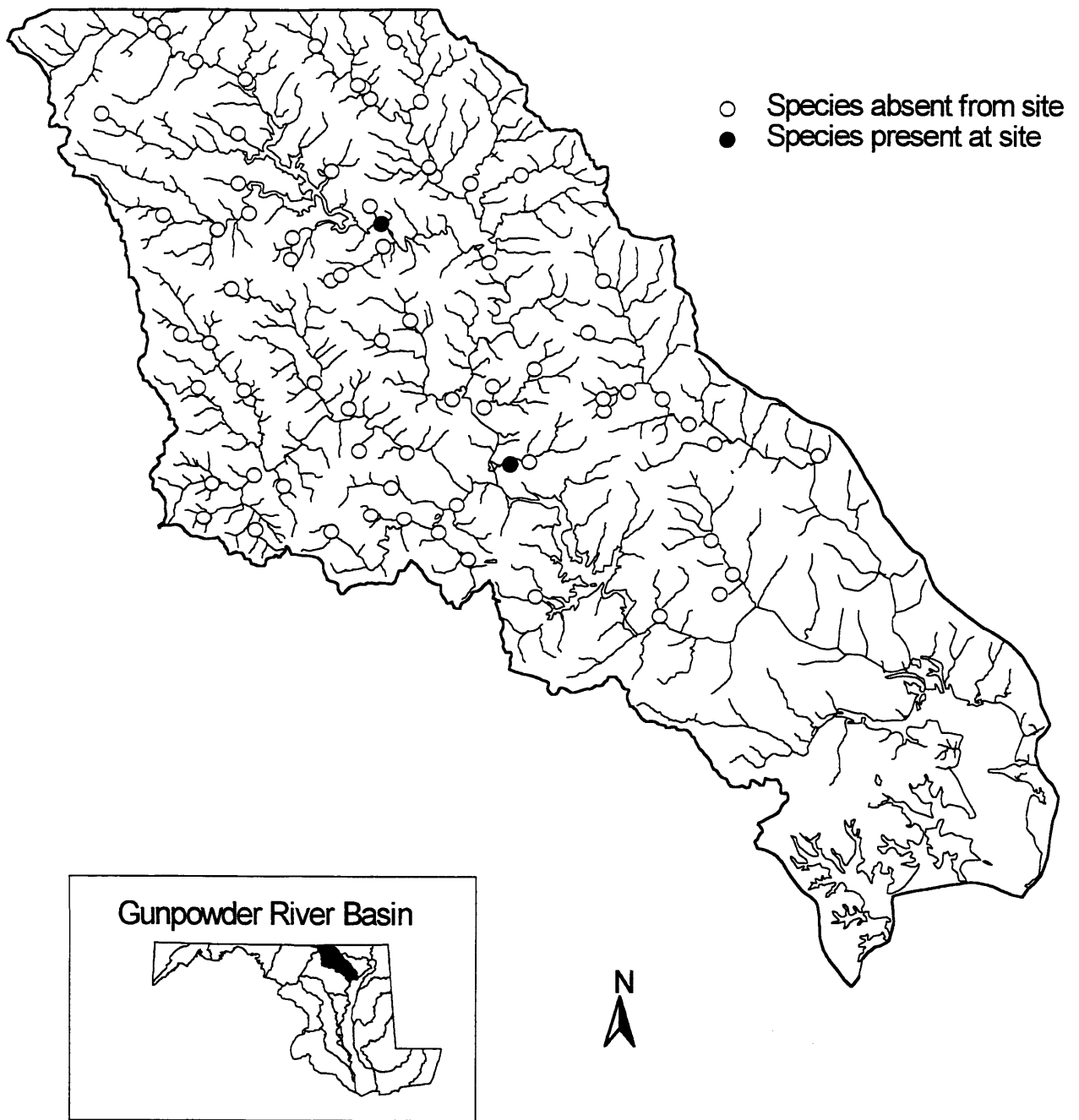


Figure E-20. Distribution of brown bullhead in the Gunpowder River basin in 1996.

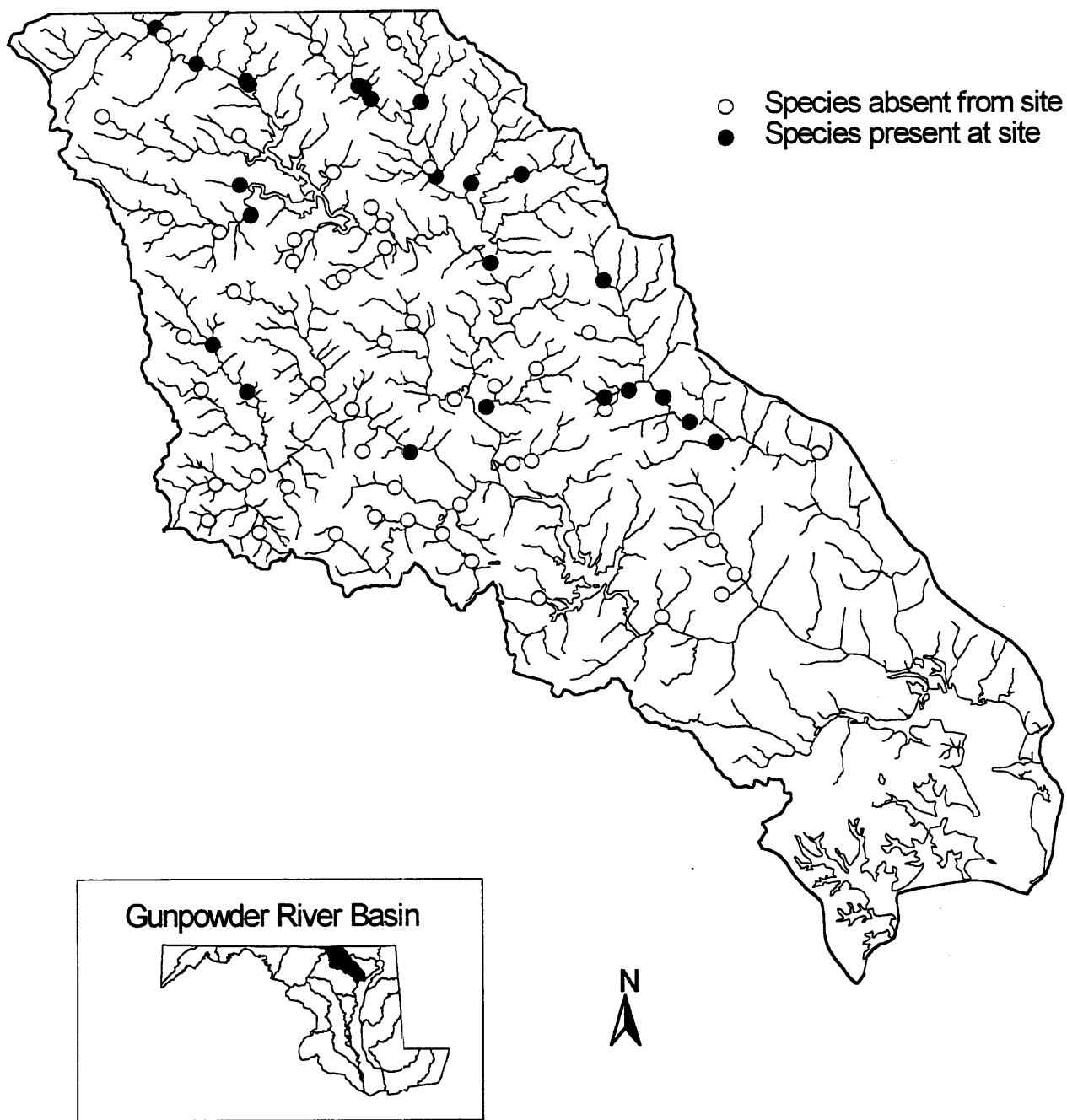


Figure E-21. Distribution of margined madtom in the Gunpowder River basin in 1996.

5 0 5 10 Kilometers

5 0 5 10 Miles

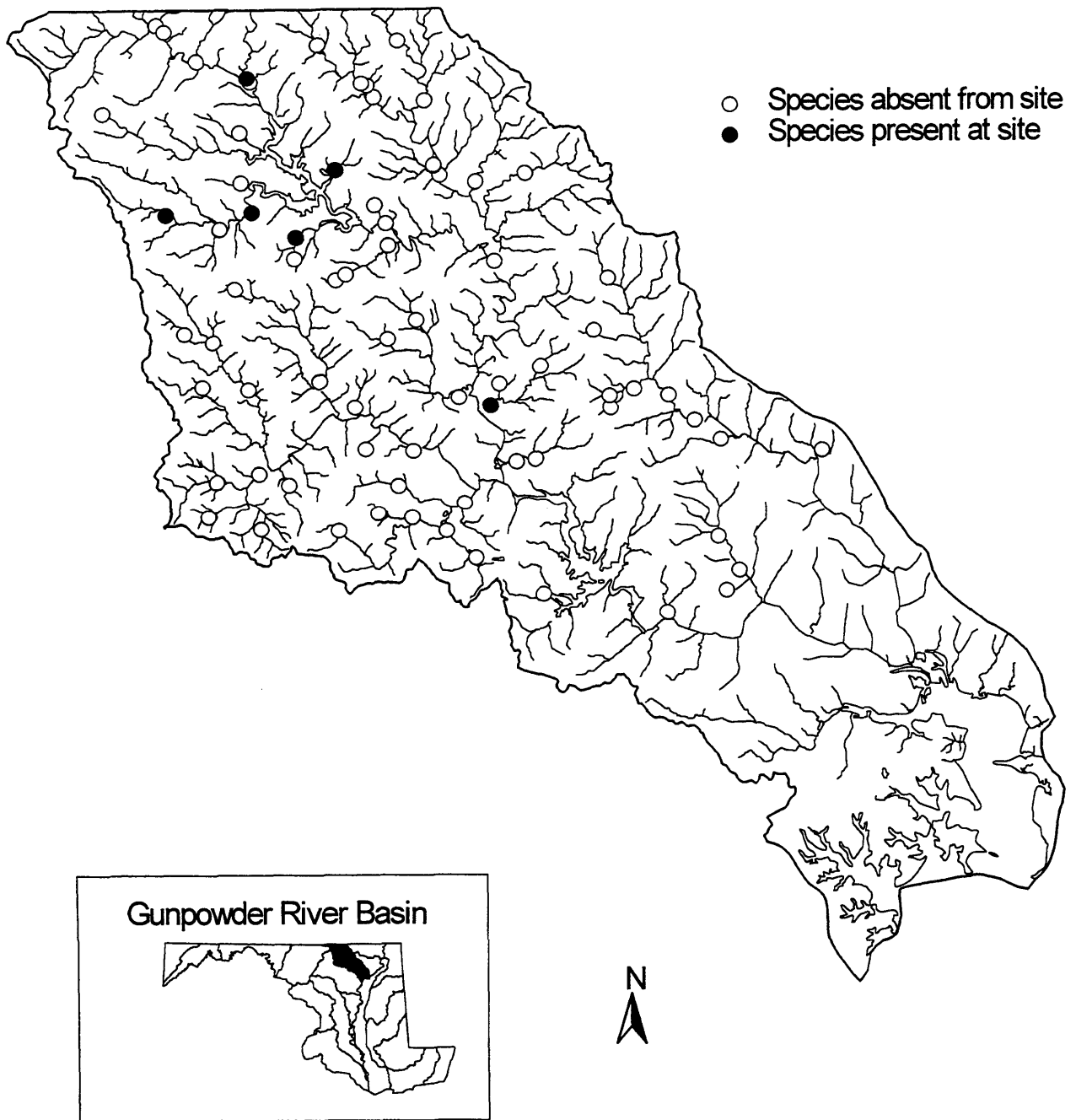


Figure E-22. Distribution of yellow bullhead in the Gunpowder River basin in 1996.

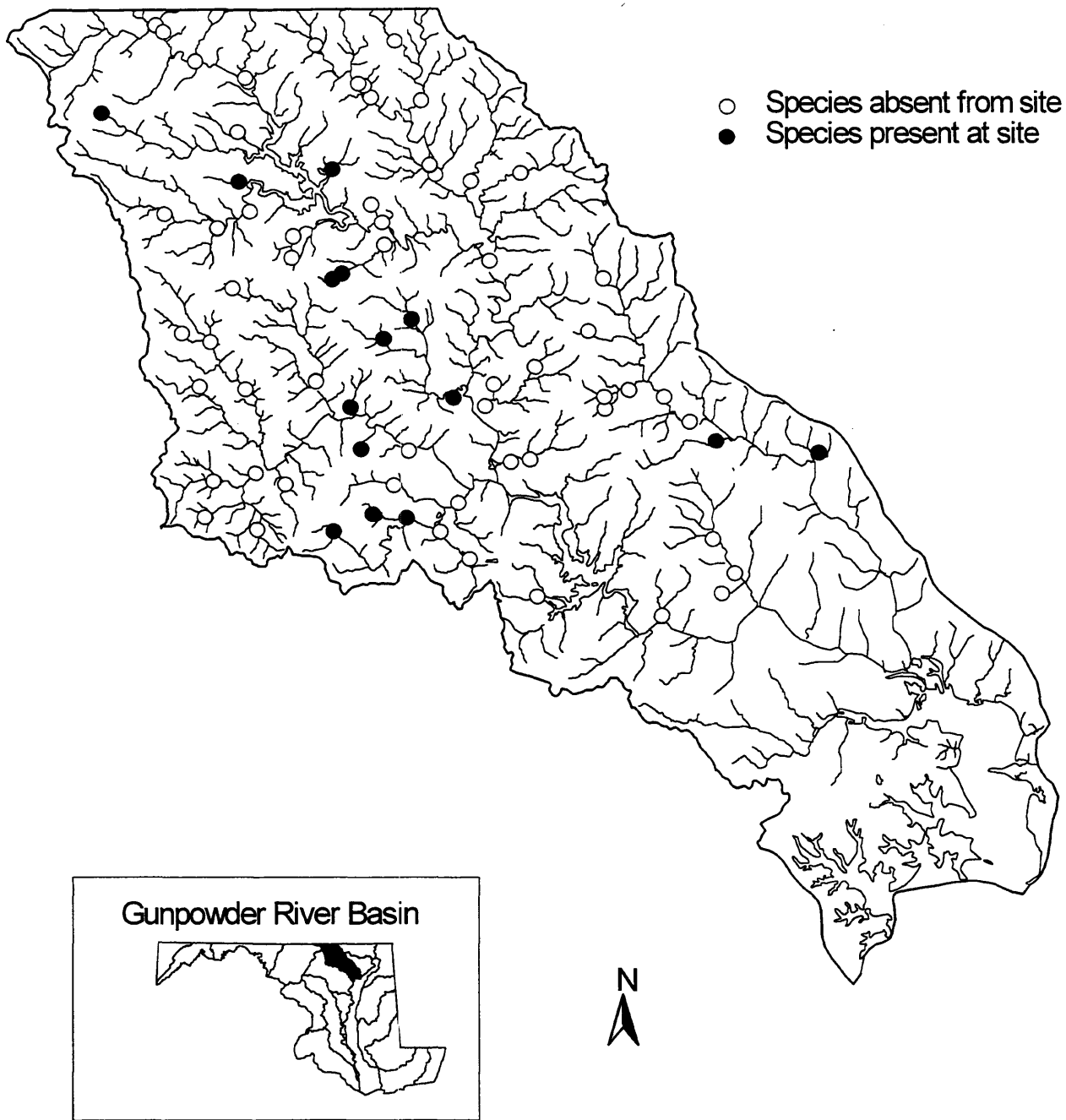


Figure E-23. Distribution of brook trout in the Gunpowder River basin in 1996.

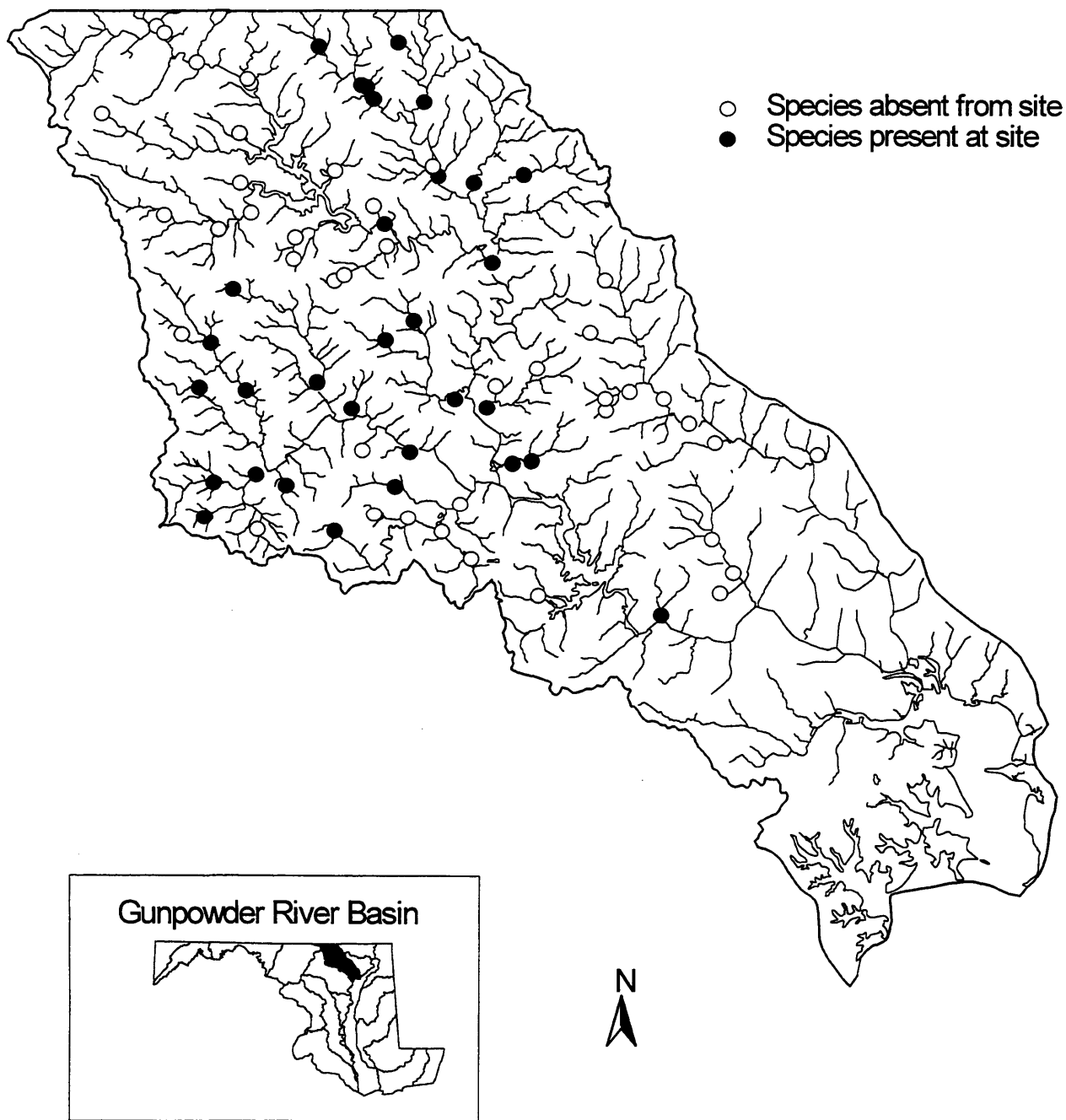
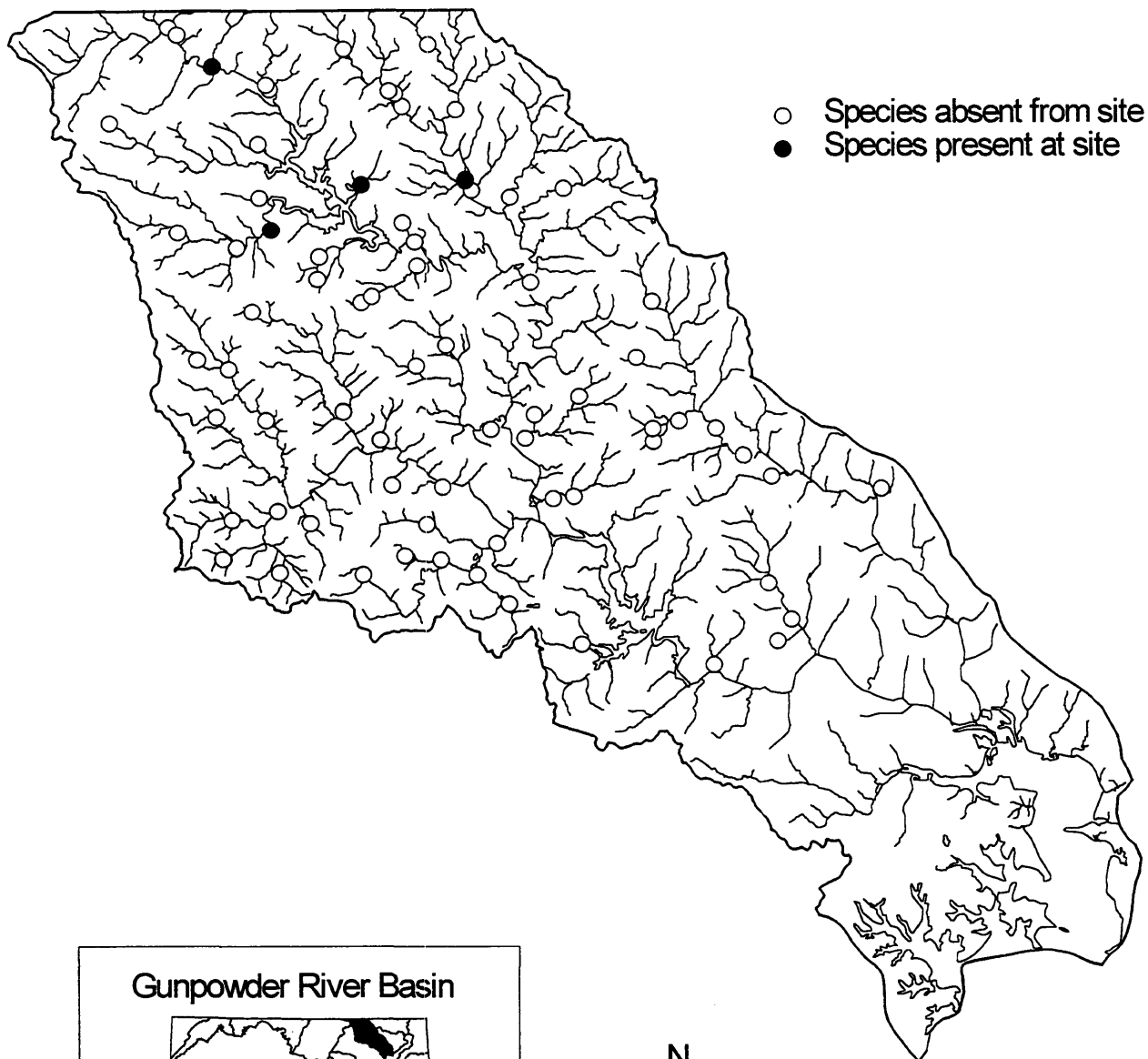
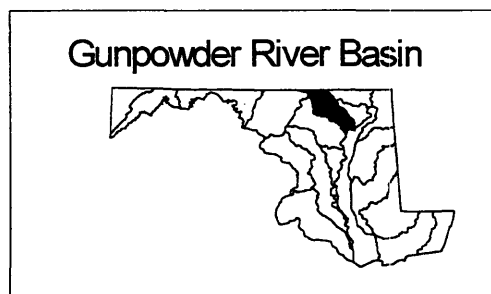


Figure E-24. Distribution of brown trout in the Gunpowder River basin in 1996.



- Species absent from site
- Species present at site



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-25. Distribution of rainbow trout in the Gunpowder River basin in 1996.

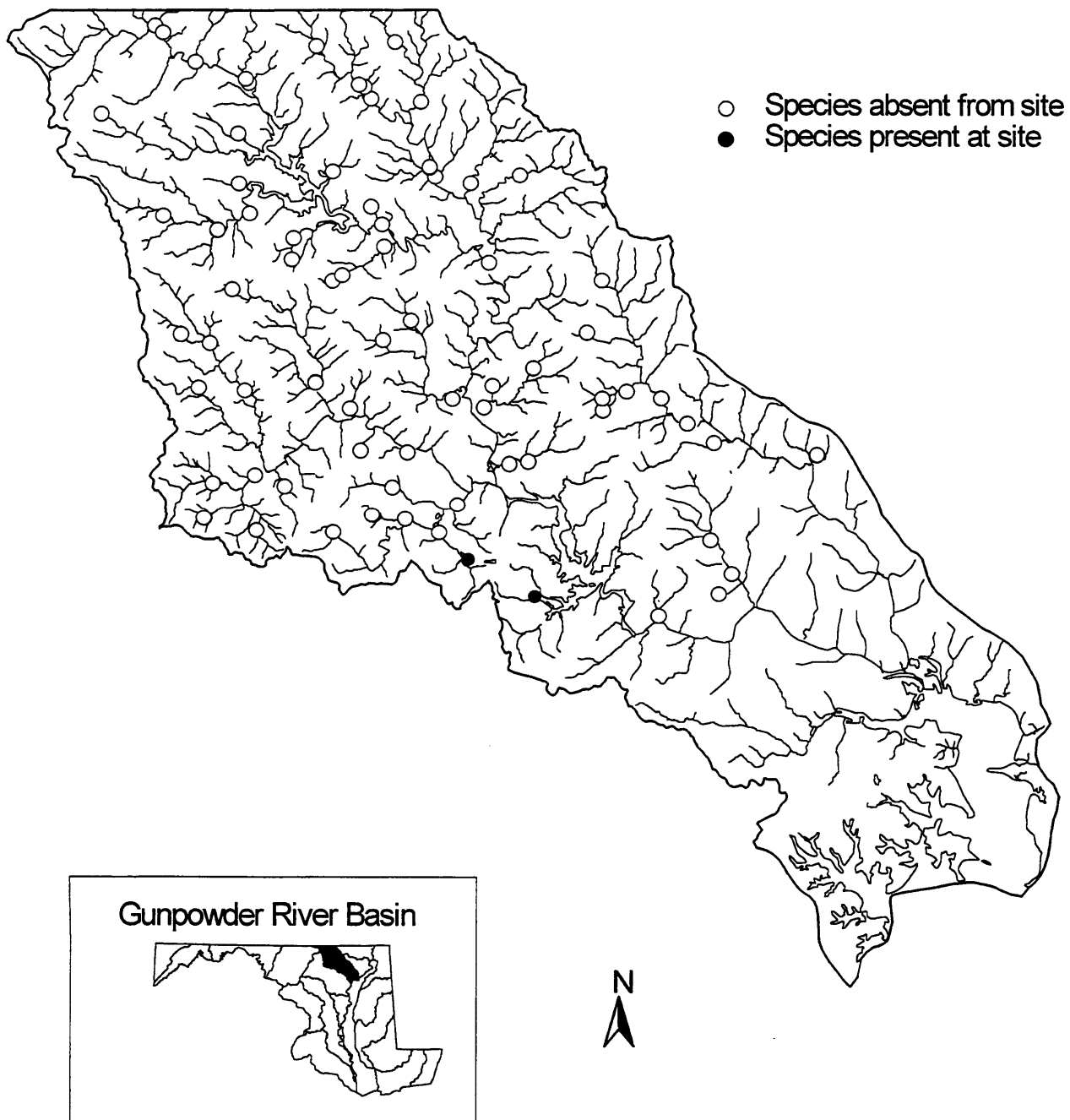


Figure E-26. Distribution of mummichog in the Gunpowder River basin in 1996.

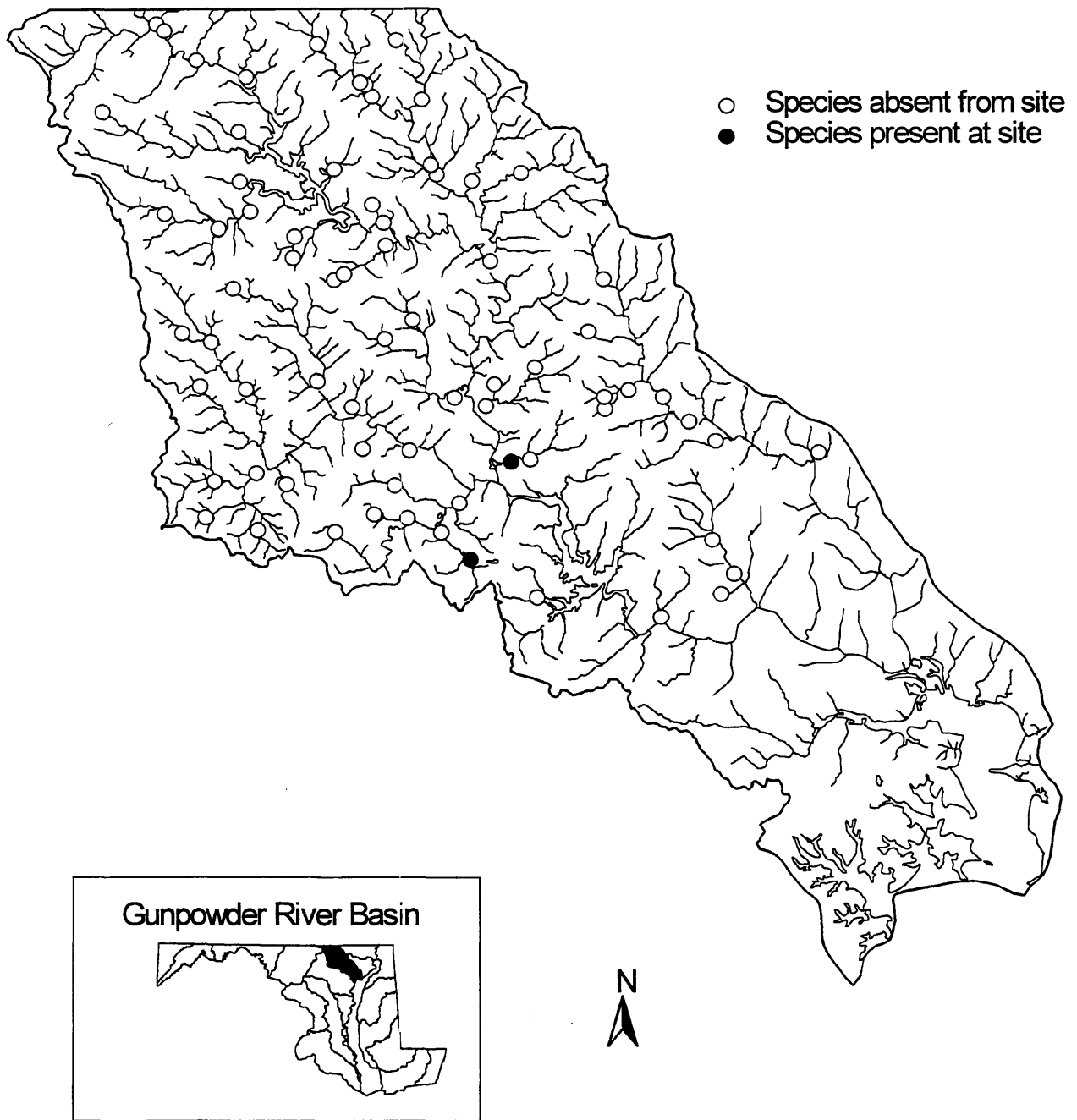


Figure E-27. Distribution of mosquitofish in the Gunpowder River basin in 1996.

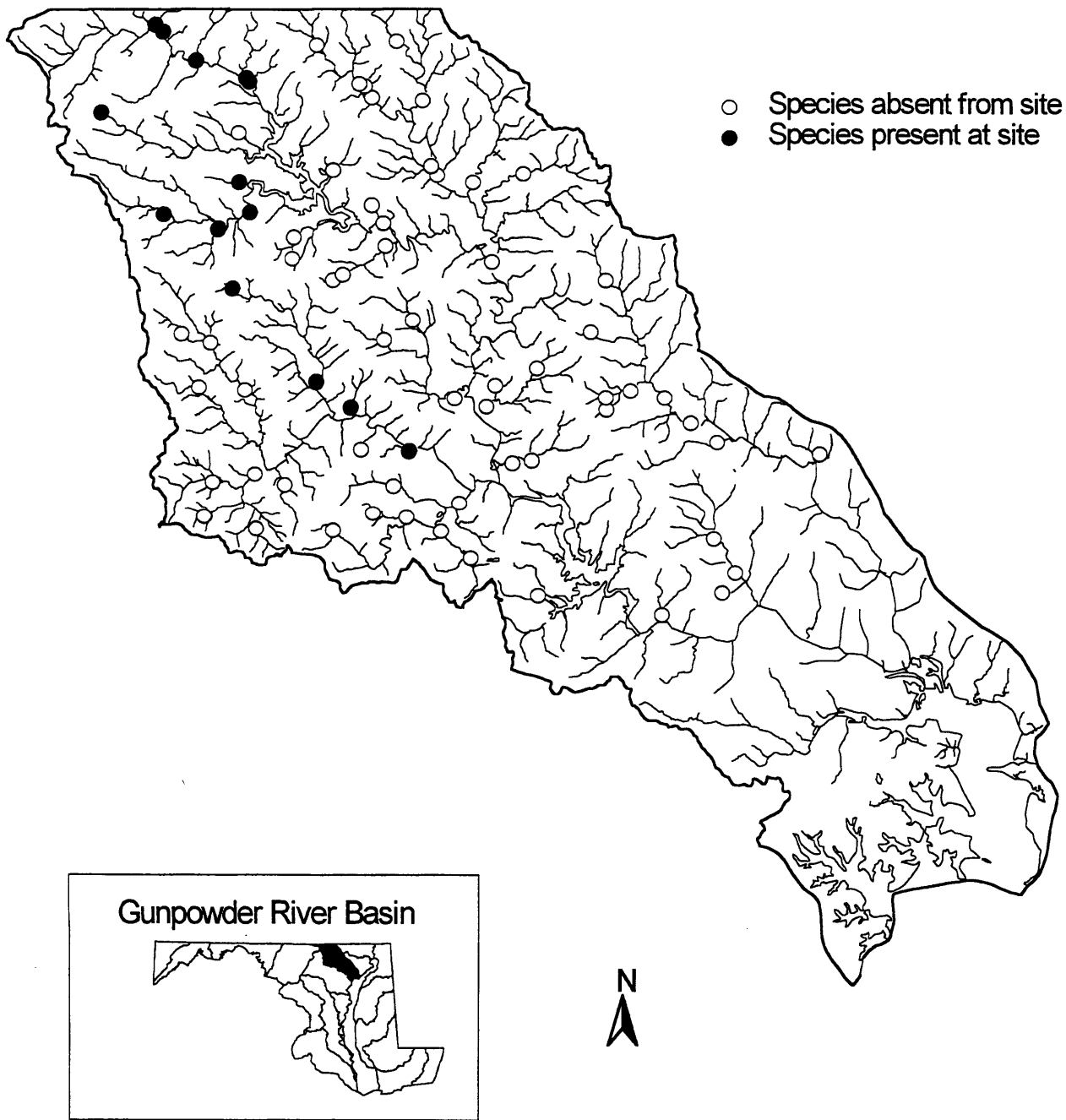
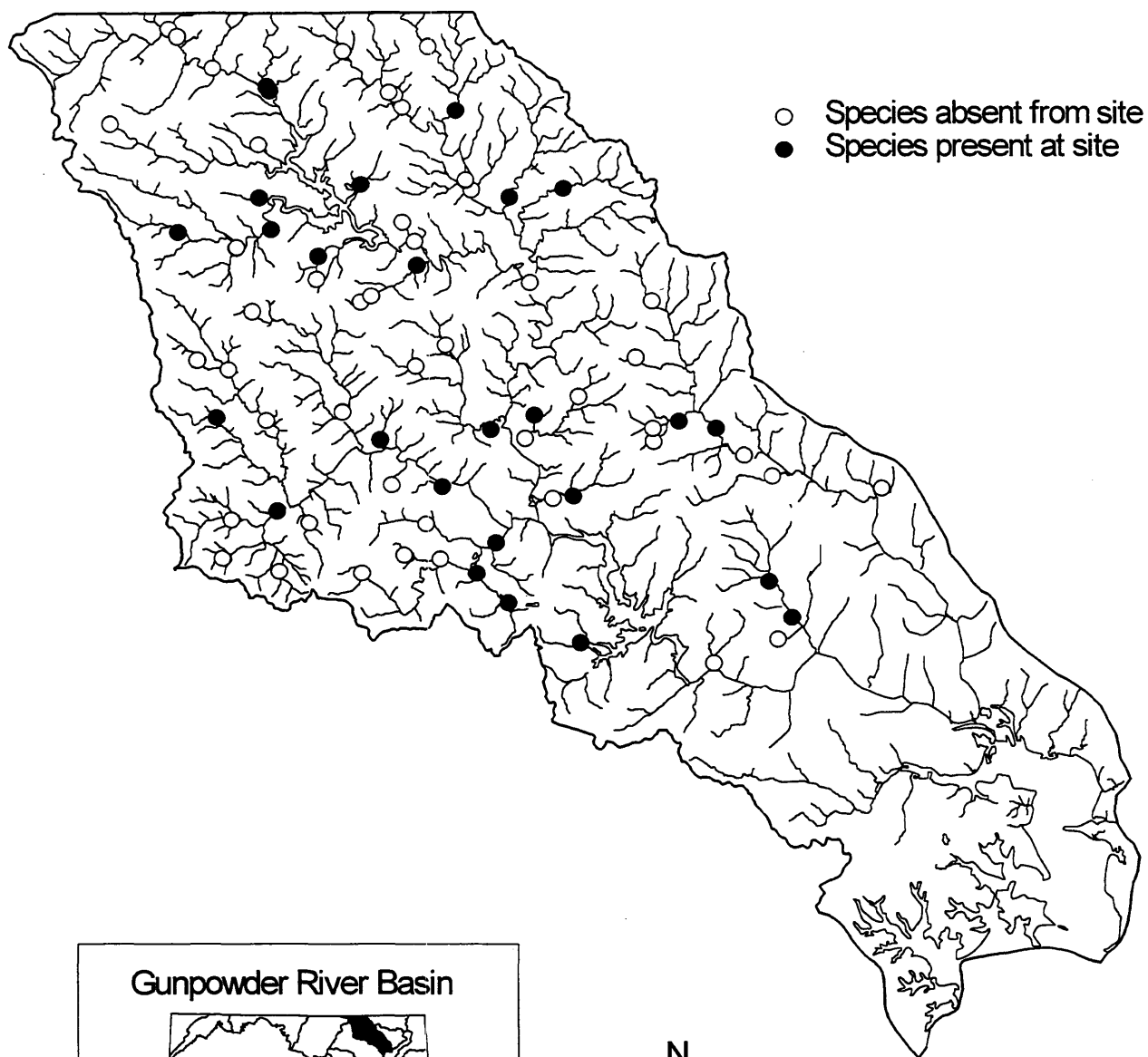
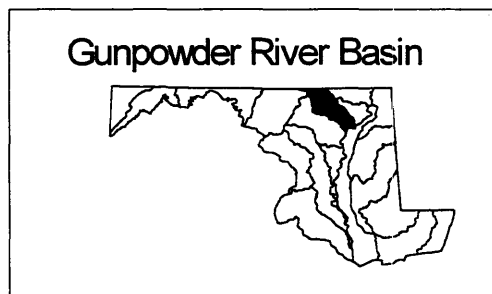


Figure E-28. Distribution of mottled sculpin in the Gunpowder River basin in 1996.



- Species absent from site
- Species present at site



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-29. Distribution of bluegill in the Gunpowder River basin in 1996.

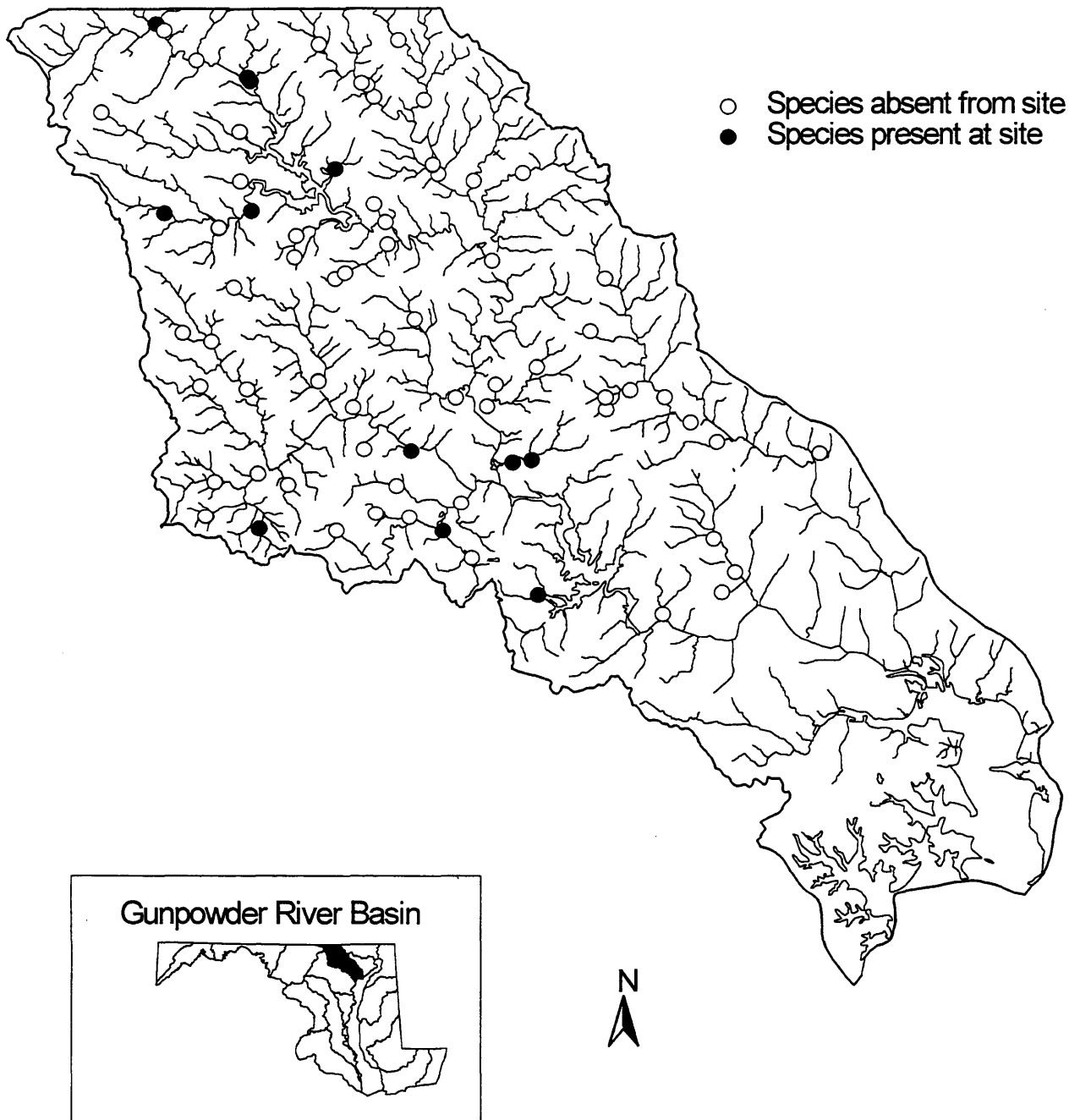


Figure E-30. Distribution of green sunfish in the Gunpowder River basin in 1996.

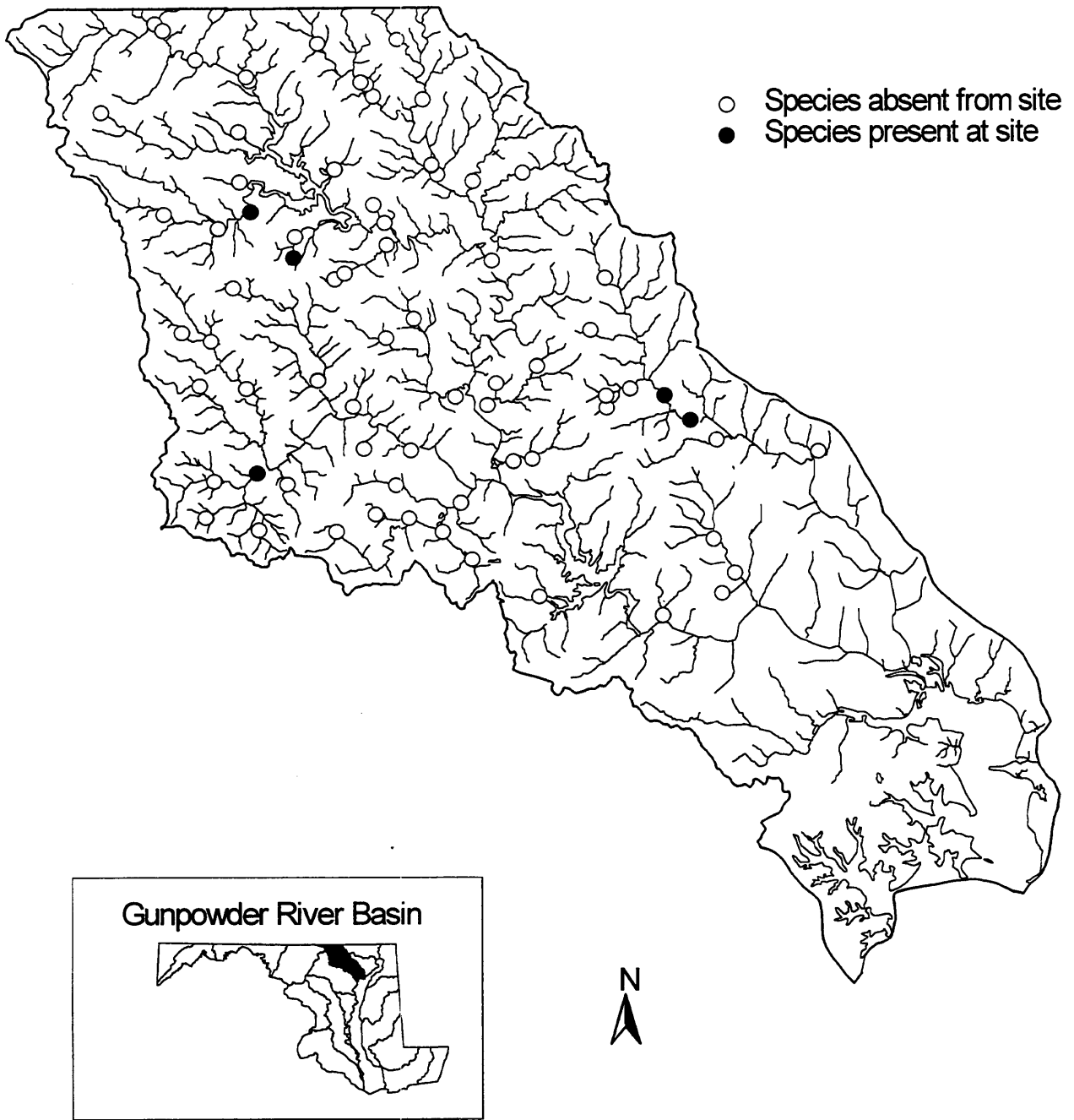


Figure E-31. Distribution of largemouth bass in the Gunpowder River basin in 1996.

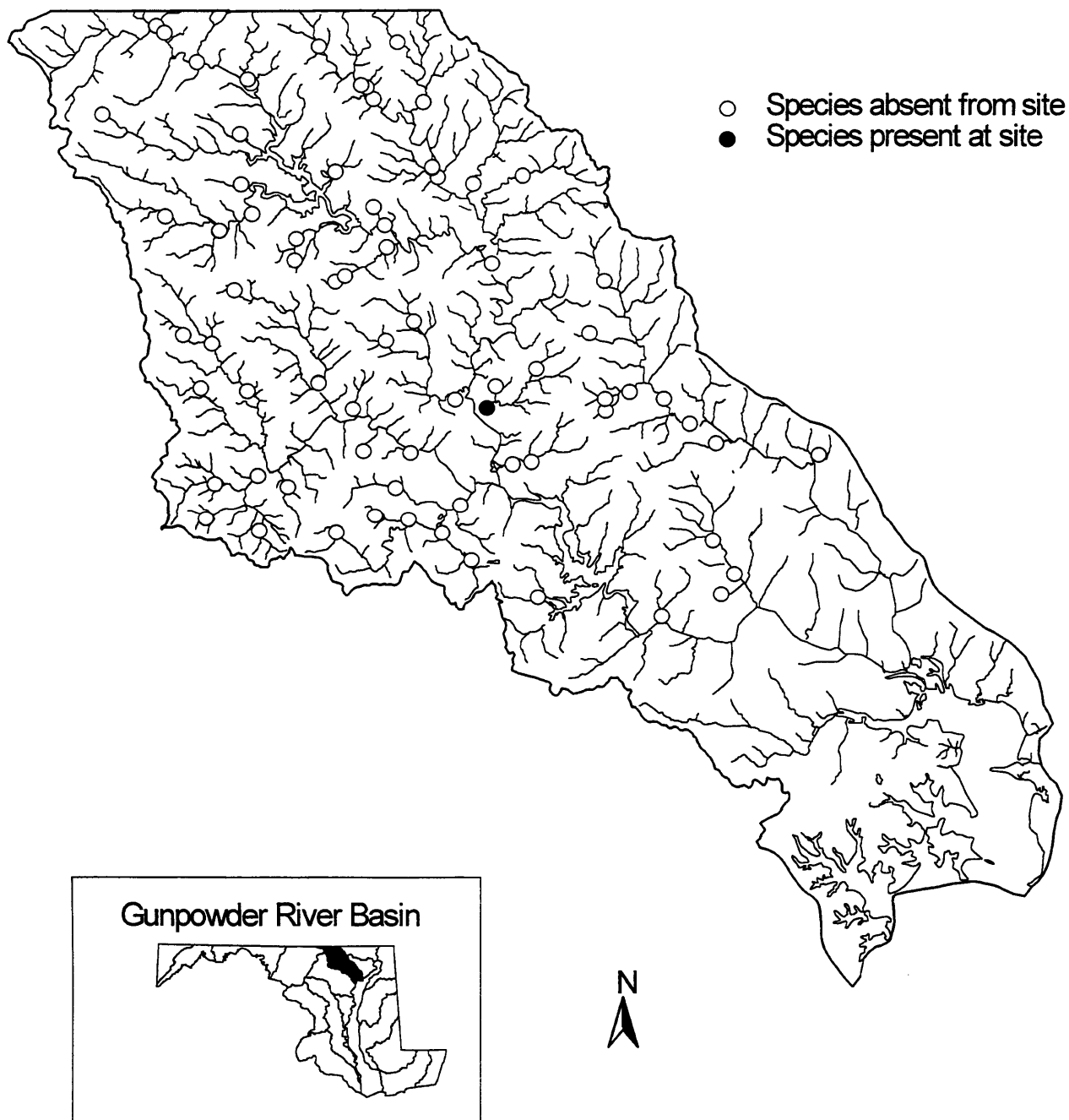
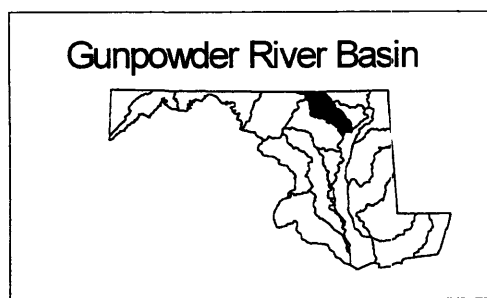
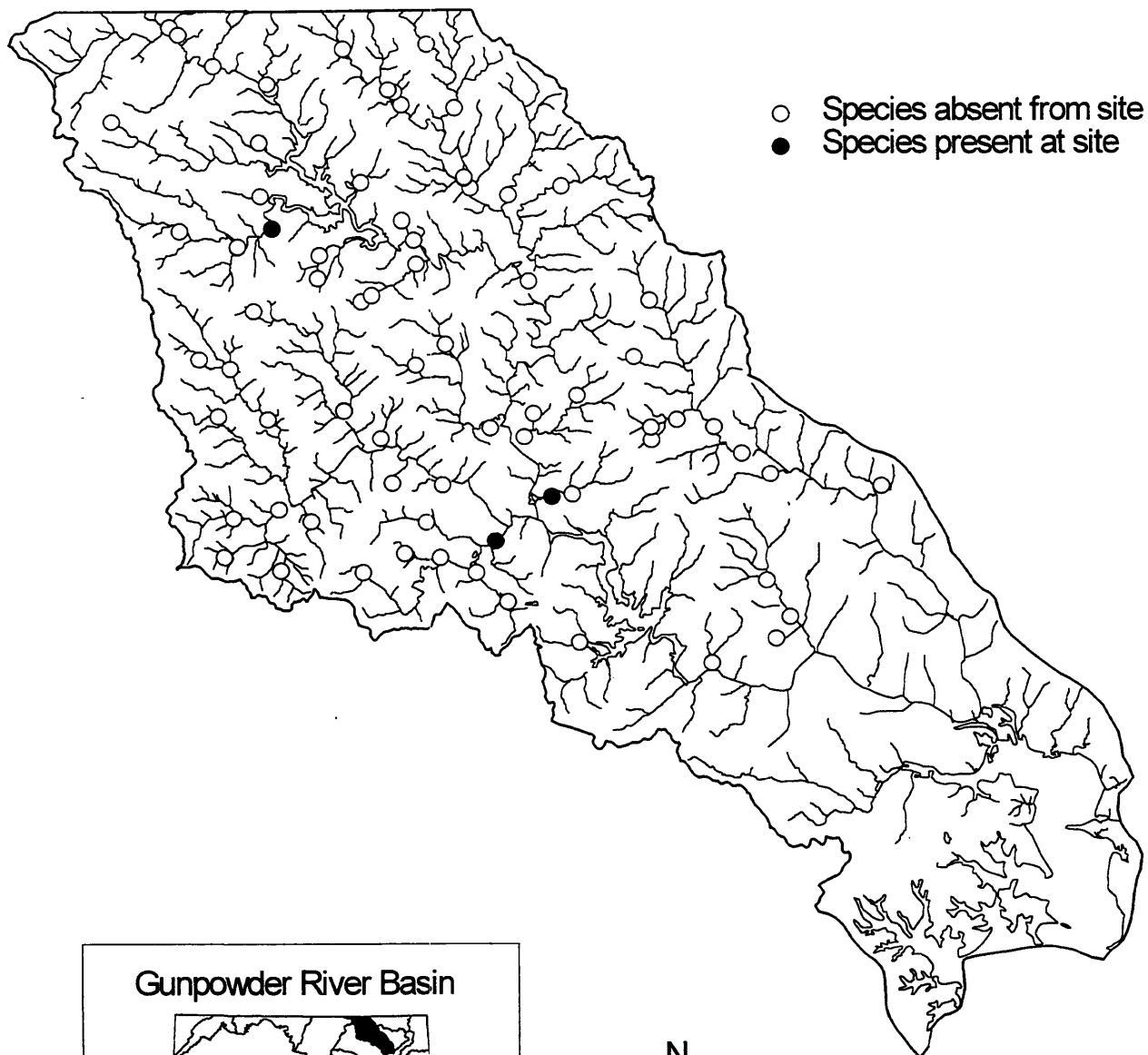


Figure E-32. Distribution of longear sunfish in the Gunpowder River basin in 1996.



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-33. Distribution of pumpkinseed in the Gunpowder River basin in 1996.

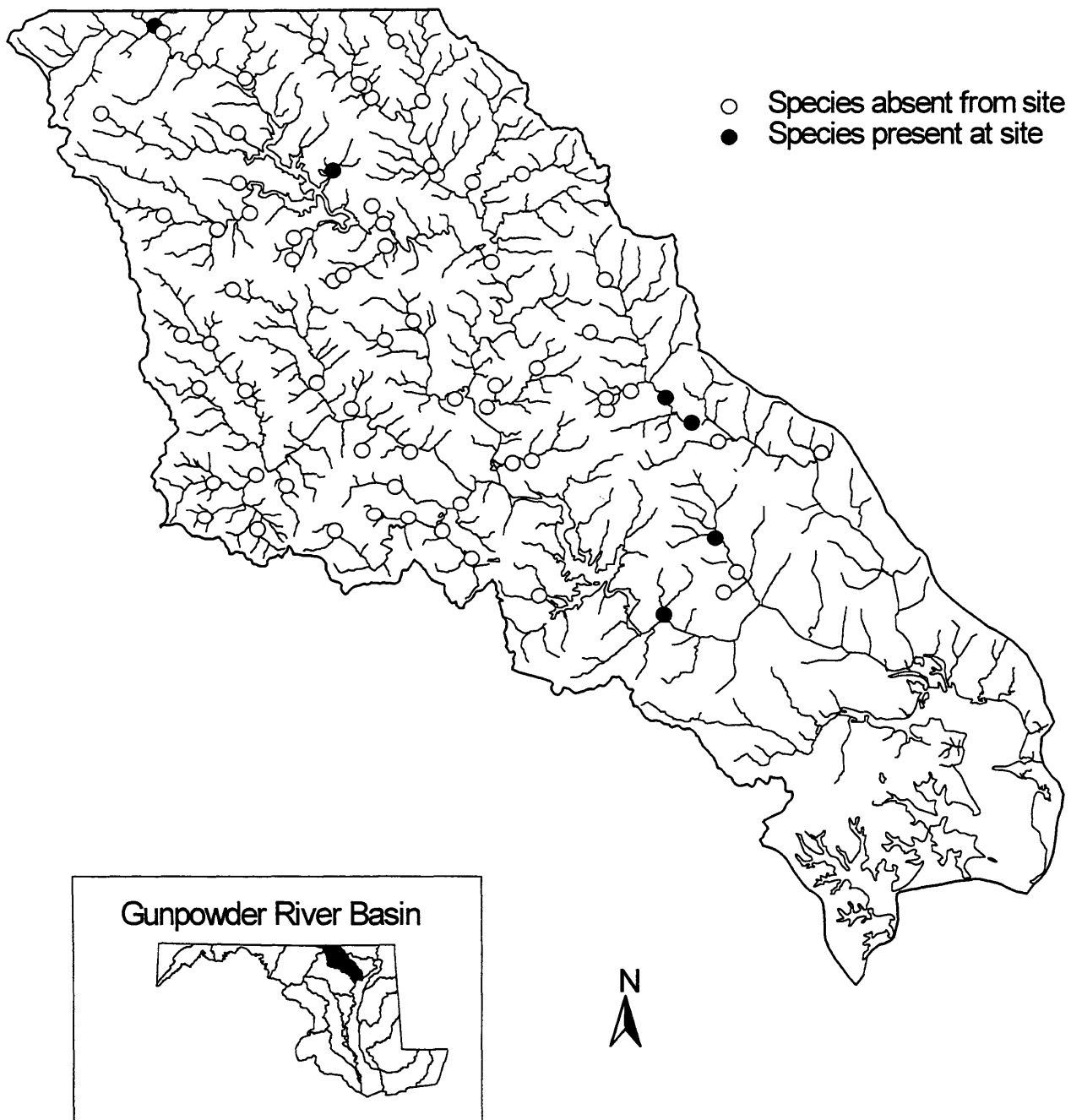
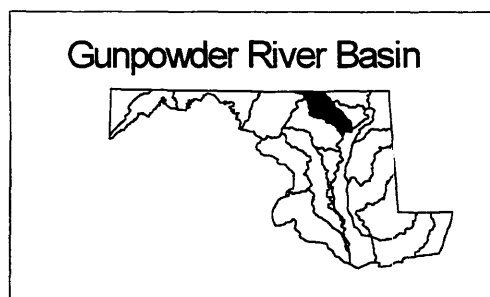
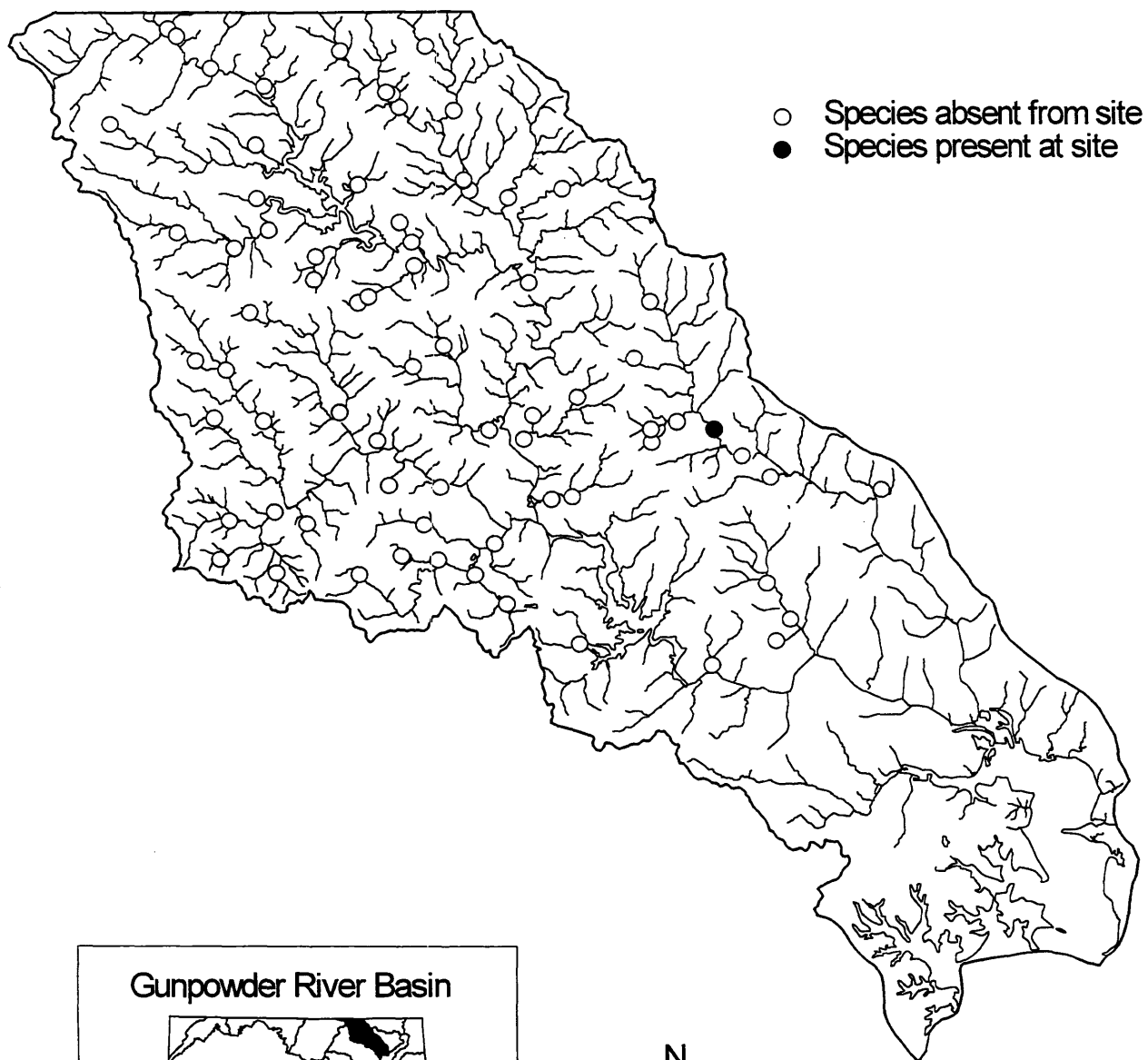


Figure E-34. Distribution of redbreast sunfish in the Gunpowder River basin in 1996.



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-35. Distribution of rock bass in the Gunpowder River basin in 1996.

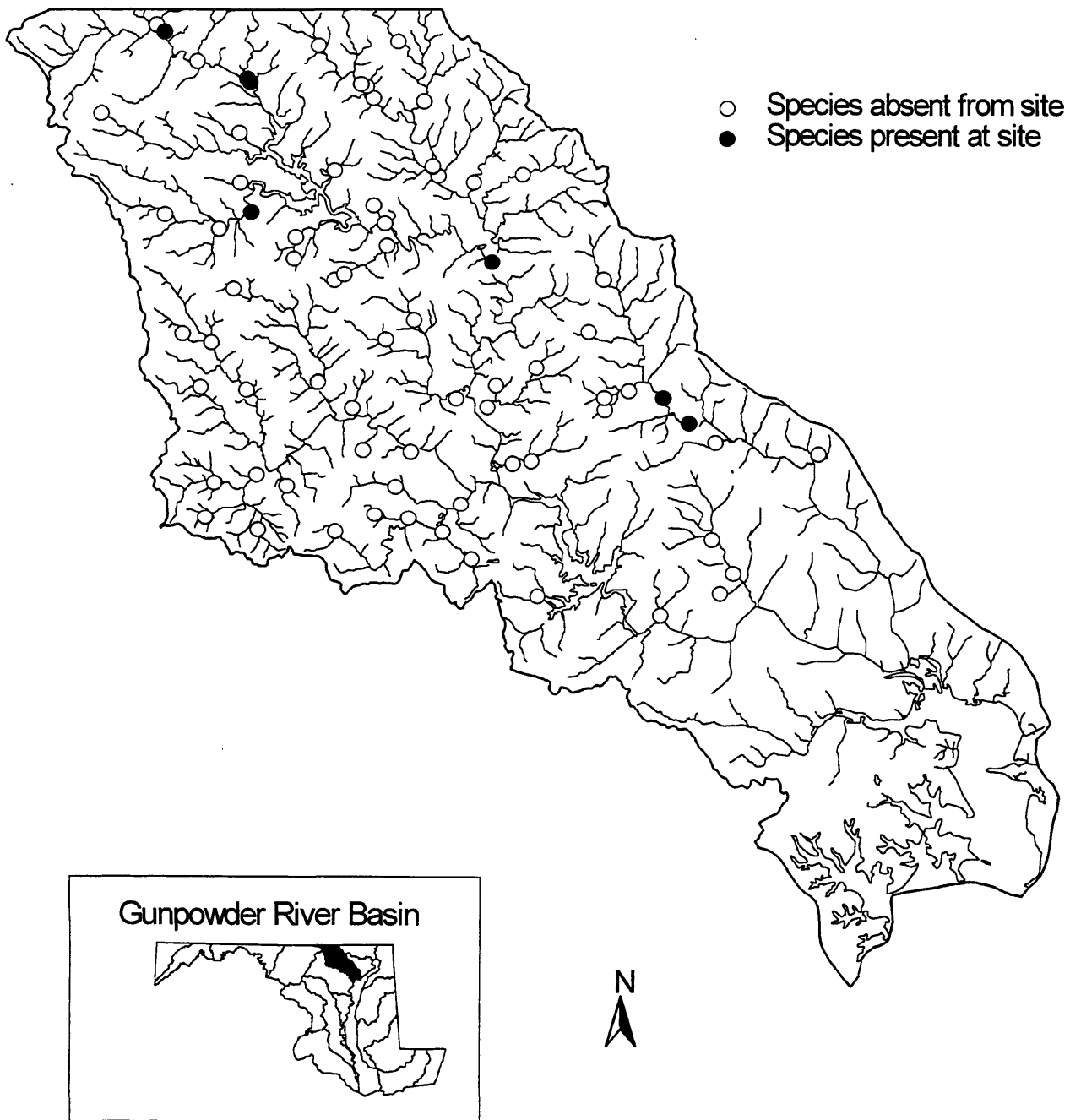
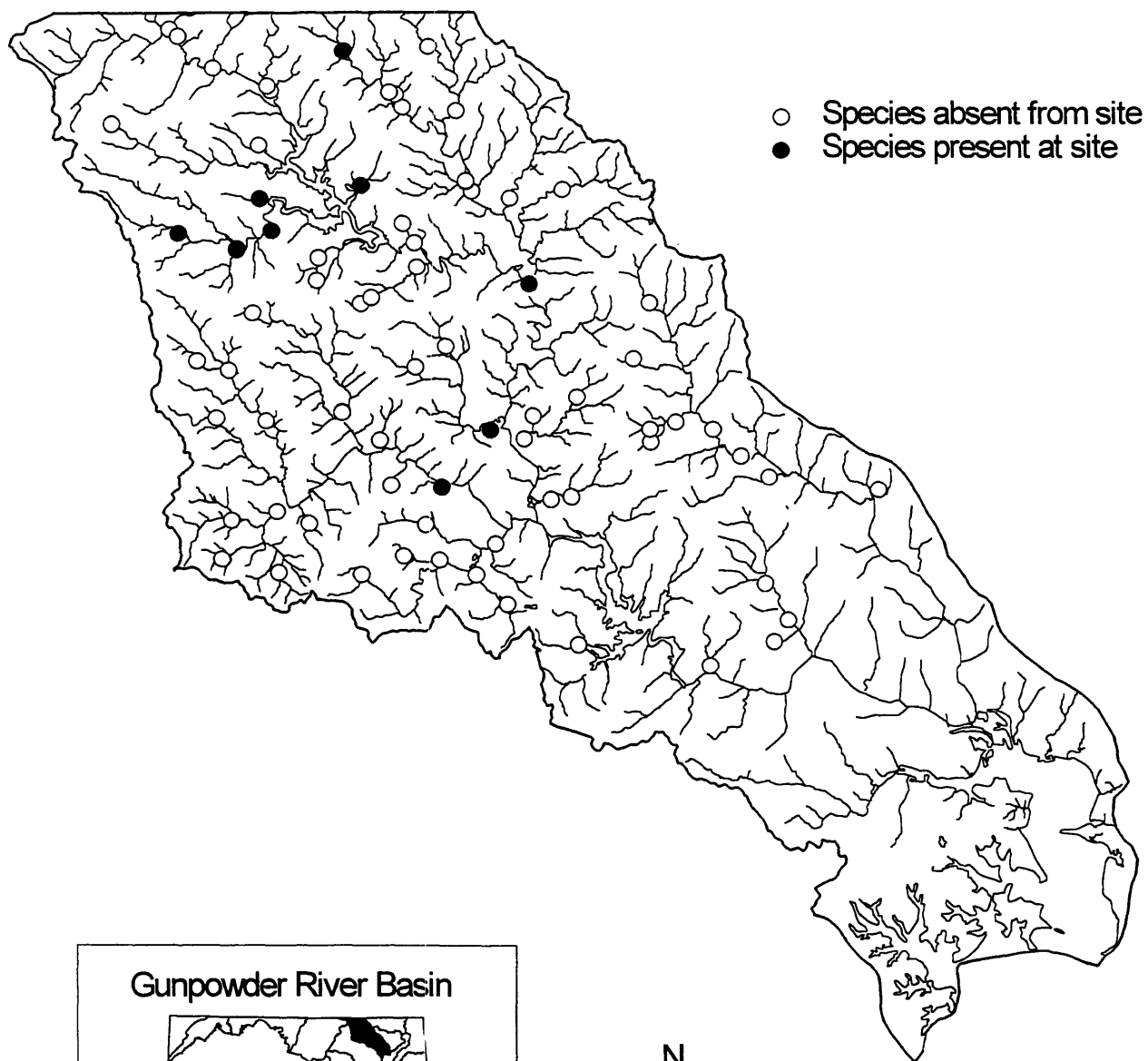
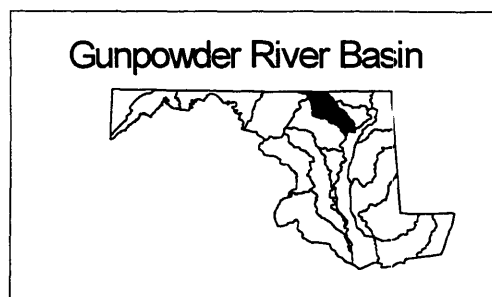


Figure E-36. Distribution of smallmouth bass in the Gunpowder River basin in 1996.



- Species absent from site
- Species present at site



5 0 5 10 Kilometers



5 0 5 10 Miles



Figure E-37. Distribution of fantail darter in the Gunpowder River basin in 1996.

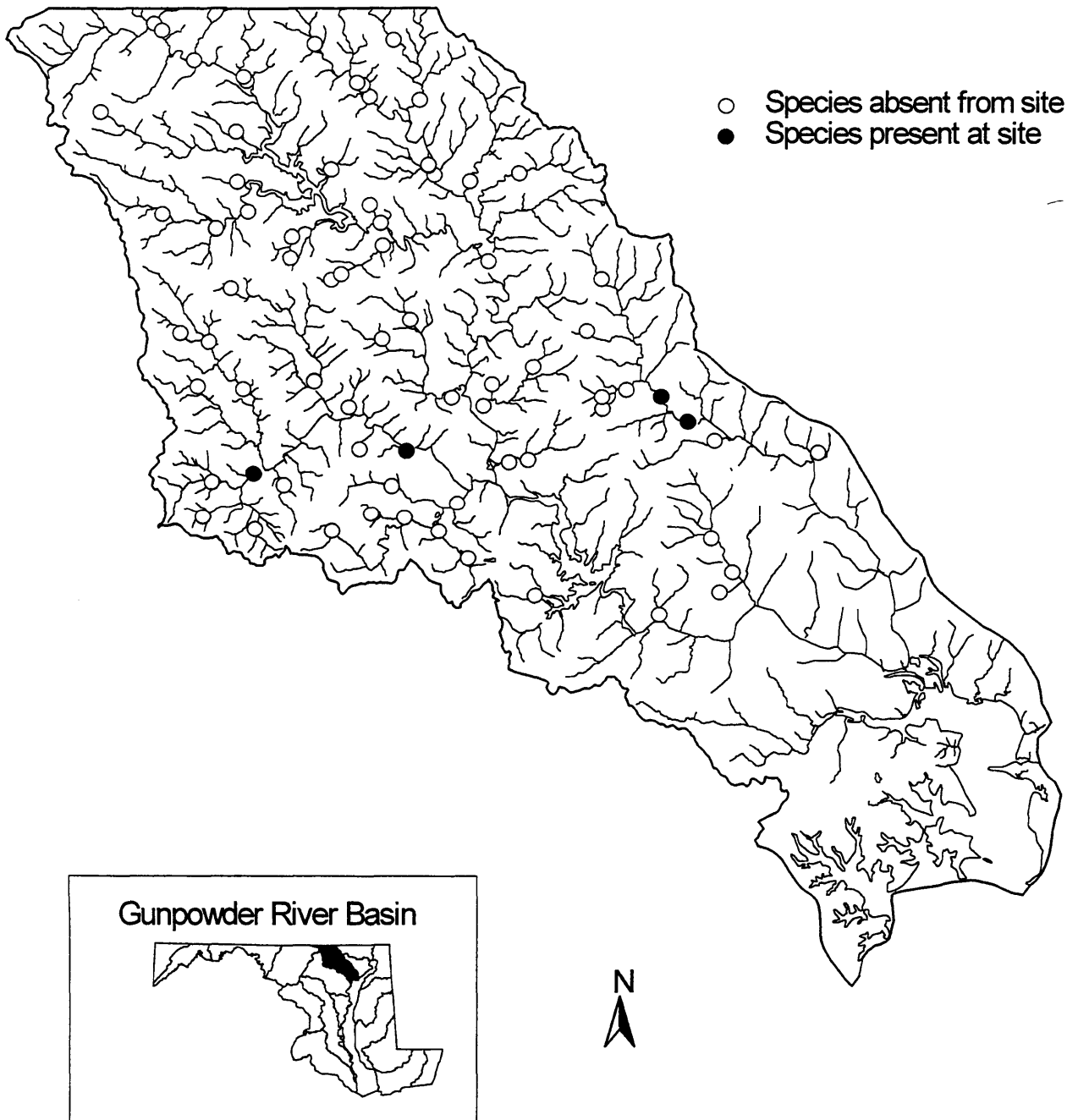
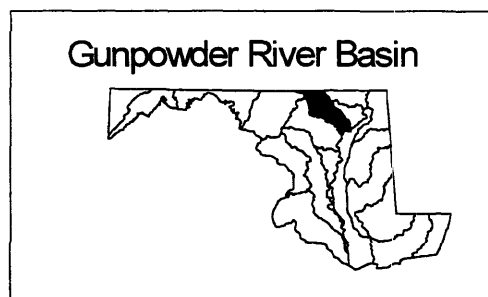
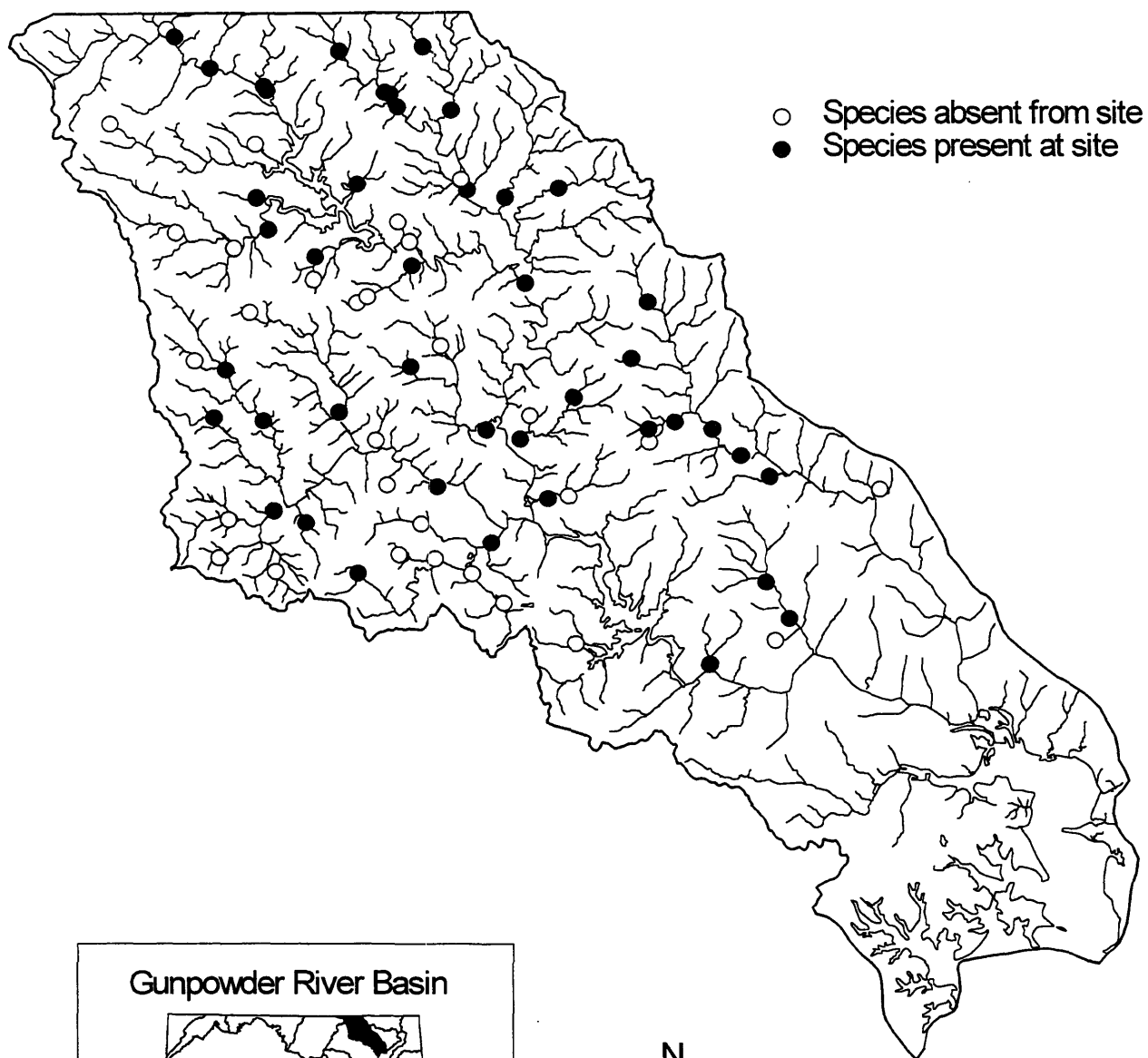


Figure E-38. Distribution of shield darter in the Gunpowder River basin in 1996.



5 0 5 10 Kilometers

5 0 5 10 Miles

Figure E-39. Distribution of tessellated darter in the Gunpowder River basin in 1996.

**BENTHIC MACROINVERTEBRATE FAMILIES SAMPLED
IN THE GUNPOWDER RIVER BASIN IN 1996**

Of the approximately 123 stream-dwelling benthic macroinvertebrate families found in Maryland, 48 were collected in the Gunpowder River basin during 1996. Dominant families included non-biting midges (Diptera:Chironomidae), mayflies (Ephemeroptera:Ephemerellidae), and caddisflies (Trichoptera:Hydropsychidae). Rare families included snails (Gastropoda:Physidae), mayflies (Ephemeroptera:Tricorythidae), and beetles (Coleoptera:Gyrinidae & Hydrophilidae).

PROBOSCIS**WORMS***(Nemertea)*

Nemertea

SNAILS, CLAMS*(Mollusca)*

Physidae

WORMS*(Annelida)*

Oligochaeta

Lumbriculidae

**CRAYFISH, SCUDS,
SHRIMP, SOWBUGS***(Crustacea)*

Astacidae

Crangonyctidae

Gammaridae

MAYFLIES*(Ephemeroptera)*

Baetidae

Ephemerellidae

Heptageniidae

Leptophlebiidae

Oligoneuriidae

Siphonuridae

Tricorythidae

STONEFLIES*(Plecoptera)*

Capniidae

Leuctridae

Nemouridae

Peltoperlidae

Perlidae

Perlodidae

Pteronarcyidae

Taeniopterygidae

CADDISFLIES*(Trichoptera)*

Brachycentridae

Glossosomatidae

Hydropsychidae

Lepidostomatidae

Limnephilidae

Philopotamidae

Polycentropodidae

Rhyacophilidae

Uenoidae

DRAGONFLIES, DAMSELFLIES (*Odonata*)

Coenagrionidae

Gomphidae

HELLGRAMMITES, FISHFLIES*(Megaloptera)*

Corydalidae

BEETLES*(Coleoptera)*

Carabidae

Dryopidae

Elmidae

Gyrinidae

Hydrophilidae

Psephenidae

Ptilodactylidae

TRUE FLIES*(Diptera)*

Ceratopogonidae

Chironomidae

Dixidae

Empididae

Simuliidae

Tabanidae

Tipulidae

Qr.
97
M.
Gr.
1967
M. 12

Gunpowder River Basin : 1215
environmental assessment of stream
conditions

**DEPARTMENT OF NATURAL RESOURCES
INFORMATION RESOURCE CENTER
NON-CIRCULATING**

DATE DUE

MAR 2 2000

Return Material Promptly

